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ABSTRACT

The 1982 Search for Excellence in Science Education project has identified 12 exemplary programs in elementary school science. Descriptions of the programs and the criteria used in their selection are presented. Chapter 1 reviews four goal clusters (developed during Project Synthesis) related to the desired state in elementary school science. These goal clusters, which focus on personal needs, societal issues, fundamental knowledge, and careers, were used as the criteria for defining excellence in these programs. Chapters 2 to 13 provide descriptions of the exemplary programs. The descriptions include: (1) information about the setting of the program (community location, size, specific features, school science, and organization); (2) nature of the program (grade, level, class sizes, curriculum outline, learning activities, evaluation techniques); (3) origin of the program; and (4) what factors contribute to the program's success and what is needed to keep it going. Chapter 14 synthesizes the ideas found in these programs and offers generalizations and recommendations related to excellence in elementary science. Among the generalizations reported are those indicating that the programs: emphasize hands-on science, inquiry strategies, and student decision-making; were teacher developed, designed, and implemented; and receive administrative and community support. (JN)

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VOLUME 1 NUMBER 2

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Elementary Science

SE 044 961

John E. Penick, EDITOR

FOCUS ON EXCELLENCE

Volume 1 Number 2

ELEMENTARY SCIENCE

Edited by

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PROLOGUE: SEEKING EXCELLENT ELEMENTARY SCIENCE PROGRAMS

By

John E. Penick

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Many descriptions of excellent ideas, activities, and complete science programs have been published, read, and reviewed; resulting in considerable improvement in science teaching and additional recognition of continuing problems. With this first year of the **Focus on Excellence** monograph series, The National Science Teachers Association hopes to provide a source of inspiration, ideas, and resource people as well as descriptions of innovative and successful practices.

For 1982, our search has been for outstanding programs in five focus areas: Biology, Elementary Science, Science as Inquiry, Physical Science, and Science/Technology/Society. For each area, we are devoting a monograph such as this describing innovative programs with a particular focus. This continuing monograph series from NSTA will highlight excellence in Middle School/Junior High Science, Physics, and Informal Science Education in 1983. Future years will see a search for excellence in school science areas, teacher education programs, and other science areas found in Science education. We feel strongly that this monograph series, **Focus on Excellence,** will play a needed and vital role in shaping science education practices and research of the future.

The 1982 Search For Excellence in Science Education began when Robert Yager, NSTA president for 1982-83, was invited to become a member of **Project Synthesis.** The perceived need for Project Synthesis came in 1976 when several National Science Foundation funded studies revealed the current state of science education in the United States. Then, in 1978, a synthesis of the more than 2,000 pages of information from those three NSF reports and from the National Assessment of Education Progress data was begun by twenty-three science educators throughout the U.S.

The Synthesis researchers worked independently in small teams, each focusing on one aspect of science education: Elementary Science, Biology, Physical Science, Science/Technology/ Society, or Inquiry. A critical part of the synthesis analysis was developing a description of an ideal or desired state for a focus area and then comparing the actual to the desired state. During the Search for Excellence, goals arising from the synthesis desired state for each of the five focus areas were used as criteria for defining excellence in a school science program.

Leading science educators (generally state science consultants) in each state were identified as chairs of committees to identify and nominate outstanding science programs in their respective states. Ultimately, 165 state nominations were submitted to the project director for consideration at the national level for 1982. Thus, the state exemplars were passed on to another set of review committees and yet another selection process.

To aid in the selection process, all nominees were asked to fill out forms detailing information on demographics, texts used, and the nature of the school. A questionnaire, developed from the desired state criteria, was completed by the nominee as an integral part of the nomination packet. In addition, the state nominees were given the major criteria for excellence and five questions to provide narrative information about their programs. These questions were:

1. Provide some information about the setting (community location, size, specific features, school science and organization)

2. Describe the nature of the exemplary program (grade, level, class sizes, curriculum outline, learning activities, evaluation techniques)

3. How does the program exemplify the 1982 criteria for SESE? (Abbreviated criteria were made available and reference to Volume 3 of NSTA's **What Research Says to the Science Teacher** was given.)

4. How did the exemplary program come into existence?

5. What factors contribute to the success of the program and what is needed to keep it going?

Nominations were divided into five groups: Biology, Physical Science, Science/Technology/Society, Inquiry, and Elementary Science. Each group was then reviewed by different teams with at least one of the original synthesis researchers on each team. Each program was compared to the desired State criteria and reviewed by at least four independent reviewers with reviewer discussion usually leading to a clear identification of the national exemplars in each focus area. These National Exemplars numbered twelve in Elementary Science, seven in Physical Science, and ten each in Biology, Science/ Technology/Society, and Inquiry. A separate monograph for each 1982 focus area is available from NSTA.

While Project Synthesis offered a desired state, these examples of excellence provide vivid views of what is already a reality. We hope you can profit by reading these descriptions, by finding inspiration and a source of ideas. The programs described range in size from small schools to Jefferson County, Colorado with more than 40,000 students in grades K-6.

Schools with exemplary elementary science programs are found in communities of 1000 to those with more than 200,000. Size of school or community does not seem to be a limiting factor in achieving excellence. Some schools have large budgets while others have almost no money at all.

Grade level is not a factor either. Science seems to work well at all elementary grade levels. While most programs have begun at a particular grade level, they all eventually spread to the rest. Not surprisingly, teachers are the most significant factor. Teachers in all of these programs are dynamic, thoughtful, young at heart, and eager to learn with their students. (If you are interested, see another monograph from NSTA, **Teachers in Exemplary Programs: How Do They Compare?)**

Chapter One describes the Project Synthesis criteria for excellence in elementary science programs. Chapters two through thirteen offer descriptions of twelve elementary programs selected as exemplary during the 1982 search for excellence. Chapter fourteen is a synthesis of the ideas found in these programs and a number of generalizations and recommendation relating to excellence in elementary science.

These programs are all exemplary in various ways but they by no means exhaust the supply of innovative and outstanding science education programs. We feel strongly that excellence exists and it exists in reasonable quantity. View these as **some** examples of excellence and be prepared to find more. At the same time, we encourage you to contact any of these exemplary programs which you feel have applicability to your own school situation.

Chapter 1: Elementary Science: A Desired State

By

Roger T. Johnson

University of Minnesota

The Search for Excellence in Science Education grew out of another National Science Foundation sponsored effort called **Project Synthesis**. These two projects signal another push for improving the teaching of science at the pre-college level. The last big push, sparked by a Russian satellite, fostered numerous secondary science curriculum programs and dozens of projects designing curriculum for elementary school science. These efforts during the 60's were supposed to change the teaching of science dramatically; making it more exciting, more like the real thing, more concrete; inspiring more students to select science careers and giving us all scientific literacy. Although it could be argued that some impact occurred at the secondary school level, the overall effect of this "revolution" in science teaching fell far short of expectations and, at the elementary school level, pretty much failed.

An examination of happenings in elementary school science instruction indicates that very few classrooms (only 8-25%) are using one of the NSF-sponsored curriculums; that most teachers (more than 65%) never even heard about these programs (Weiss, 1978); and that inquiry teaching with concrete materials is difficult, has been tried and didn't work, and does not help the student get ready for later schooling (Stake & Easley, 1978). The Project Synthesis report described the typical elementary science experience:

> Most often science is taught at the end of the day, if there is time, by a teacher who has little interest, experience, or training to teach science. Although some limited equipment is available, it usually remains unused. The lesson will probably come a textbook selected by a committee of teachers at the school or from teacher- prepared worksheets. It will consist of reading and memorizing some science facts related to a concept too abstract to be well understood by the student but selected because it is "in the book."
>
> Pratt, in Harms & Yager, 1981

With this description of elementary school science, one could wonder where a search for excellence might lead. However, although this description might describe many classrooms, it does not describe them all. The purpose of the Search for Excellence was to find the exception, not the norm, the classroom where science was being taught effectively and appropriately. We did not find them all, but we found some and they are described in this monograph. More important than merely finding these exemplary settings, the Search has tried to shed some light on factors inspiring and maintaining these programs. How did they develop? How did they survive a strong "back to the basics" movement? What key features led to their implementation and maintenance?

If there is to be a new push in science education, it will have to be more effective at the elementary school level than the last one. Specific information about how an effective program develops is necessary. Even without the growing concern about science instruction outside the field, we in science education need to know that there are good things happening in some classrooms and we need to know something about what makes these classrooms "tick" so we can encourage more of them.

In seeking exemplary science programs, the Search for Excellence faced the significant problem of identifying criteria for an effective science classroom looked like. Fortunately, this task had been faced and met by its predecessor, Project Synthesis.

Project Synthesis

Project Synthesis, directed by Norris Harms at the University of Colorado, and conducted by 23 nationally recognized educators established what science education should look like in pre-college classrooms. Then, they compared that to what was actually happening and made recommendations about a variety of discrepancies found. Project Synthesis, funded in 1978 by NSF, had perfect timing. Material on what ought to be happening in science instruction had been accumulating for over twenty years and a summarizing analysis was long over-due. At the same time, a set of comprehensive and unique data bases related to science education were just becoming available. Three extensive NSF-funded studies had just been completed: a close look at teachers, schools, and science classrooms (Weiss, 1978); an intensive literature review examining science education practices from 1957 to 1975 (Helgeson, et al., 1977); and a set of case studies on science classrooms (Stake & Easley, 1978). These studies represented over 2000 pages of data on science education. In addition, the National Assessment of Educational Progress (NAEP, funded by the Office of Education) had just completed its third assessment of the science knowledge, skills, attitudes and educational experiences of pre-college science students (National Assessment, 1978).

Project Synthesis created five working teams of science educators (biological, physical science, science as inquiry, science/technology/society, and elementary school science), each facing the challenging task of summarizing "Desired States" for science education based on societal indicators, foundation reports, philosophical statements and other writing dating back to the Woods Hole Conference. In addition, they were charged with synthesizing the "Actual States" in science education from the current data bases. In a second phase, discrepancies between desired and actual states were identified and recommendations were made on how to close the gaps (Harms & Yager, 1981).

Desired States of Elementary School Science

The Elementary School Science focus group developed sets of general statements about what "ought to be" in three major categories of science instruction: Student Outcomes, Program Characteristics, and Program Implementation. These statements and the broader findings of Project Synthesis provided the Search for Excellence with a perspective for selecting and describing elementary science programs. A more extensive description of the Project Synthesis findings on elementary school science can be found in **What Research Says to the Science Teacher,** Volume 3 (Pratt, in Harms & Yager, 1981).

In exploring the area of student outcomes for elementary school science, the nature of the young child with a growing, stretching, exploring intellect was the major focus rather than development of detailed concepts in preparation for secondary school science. The picture that emerges is a ". . . place to excite students' curiosity, build their interest in their world and themselves and provide them with opportunities to practice the methods of science." In that exciting place concepts develop from the introduction of phenomena to be observed, compared, described and analyzed rather than a need to cover basic content in all science areas (Pratt, in Harms & Yager, 1981). With this picture in mind, the Project Synthesis Elementary Science focus group described student outcomes in four areas: Personal Needs, Societal Issues, Academic Preparation, and Career Education/Awareness. A sampling from each of these areas gives an idea of the Project Synthesis perspective:

* **Personal Needs:** students will possess a variety of skills and procedures to make rational decisions and evaluate personal consequences.

* **Societal Issues:** students will feel custodianship (collective responsibility for the environment), recognize that science will not provide "magic" solutions or easy answers, and that hard work and the use of the processes of science may "resolve" (rather than "solve") problems.

* **Academic Preparation:** students will develop an understanding of information and concepts from a wide variety of topics selected from life, earth, and physical sciences with many of these topics selected for the sole reason that they are interesting to students at that age.

* **Career Education/Awareness:** students will recognize that scientists and technicians are a heterogeneous, personal, and human group of people (both sexes, different ethnic background, handicapped and not).

Program characteristics tending to produce those kinds of student outcomes include situations where genuine alternatives exist to be argued and dealt with by the students. Problems should grow out of first-hand experience with students actively involved in identifying problems and gathering data. It was not considered desirable to draw tight lines around science instruction but to allow a topic to wander into other areas of the curriculum when possible.

Program implementation should be done in such a way that:

1. all children have equal access to science instructional resources from teachers who have sufficient experience and knowledge to feel confident about teaching science,

2. teachers understand the developing nature of the students with whom they are working,

3. teachers demonstrate ability to use appropriate teaching strategies (structuring interactions among students appropriately, questioning strategies, handling of materials),

4. school district policy provides for an adequate amount of time committed to science teaching with clear expections that science will be taught and taught appropriately,

5. the science program provides enough concrete materials to allow individuals or small groups to each have a set, with effective systems for getting appropriate materials to teachers each time they need them.

Discrepancies and Recommendations

The discrepancies between Desired States and Actual States were numerous and in some instances, dramatic. Clearly, efforts over the last 20 years by science educators, scientists, and child psychologists to make science in the elementary school more appropriate largely have been ignored. Science teaching at the elementary school level is much the same now as it was in 1955 (Helgeson, et al., 1977). The following discrepancies represent some of the Project Synthesis findings:

1. While it is desired that all children receive appropriate science instruction, there is evidence that science is a low priority in the elementary school classroom and often not taught at all (Stake & Easley, 1978).

2. While it was desired that science instruction include experiences aimed at Personal Needs, Societal Issues, Academic Preparation, and Career Education/Awareness, the most frequently used elementary school science programs concentrated on academic information and ignored the other areas except for didactic material on personal health (Pratt in Harms & Yager, 1981).

3. While it is desired that elementary school science be taught with real alternatives, real problems, and concrete materials, there is evidence that science is usually in a didactic manner using a single text (Helgeson, et al., 1977; Weiss, 1978). The most frequently used texts showed very few efforts to be interdisciplinary, provide alternatives, or offer any first-hand experiences. Little evidence exists that science teaching reflects how children learn (Pratt in Harms & Yager, 1981).

4. While it is desired that teachers use a variety of teaching strategies including question asking, structuring students to work in small cooperative groups, encouraging constructive arguing, and encouraging alternative answers, it was found that science instruction, when it occurs in the elementary school classroom, was singularly routine with the teacher teaching from a text to the whole class through lecture/discussion (Helgeson, et al., 1977; Weiss, 1978).

Search for Excellence in Science Education

Recognizing the gap between what ought to be happening in elementary school science instruction and what is happening, the Search sought classrooms which approached the ideal, or desired states, of Project Synthesis. Working through the science consultants in State Departments of Education, 165 programs around the nation were nominated in the five areas (biology, physical science, science/ technology/society, science as inquiry, and elementary school science). The elementary school science nominations were examined by a national team including representatives from Project Synthesis. Twelve elementary programs were selected for this monograph. It is important to understand that these programs did not "win" anything but instead matched a carefully selected set of criteria. These programs all had attributes closely matching the Synthesis summary of what elementary school science ought to be.

It may be helpful in reading about these programs to know some general concerns about elementary school science unearthed by Synthesis:

1. The last National Assessment added questions measuring attitudes toward science. It was alarming to see that although nine-year olds were reasonably positive about science with over four-fifths stating they were interested in science, only about half said they felt excited or successful in science. When they were asked to rank science as a subject, only 6% ranked science as their favorite while 24% listed English and 48% named mathematics. The 13 and 17 year olds were increasingly less positive as many said they didn't want to take any more science than required and an equal number were not sure whether they wanted to or not. Less than half of the 13 year-old students expressed interest in a science related career (NAEP, 1978).

   There is a concern that elementary school science should build positive attitudes toward science, a desire to take more science, and an understanding of the scientific process. In visiting one of the programs profiled here, I asked students how they would feel if the science program had to be eliminated. "I would move to another school," was one reply. Another student said, "I would die!" It was obvious when watching these students work that they felt very positive about themselves and the time they spent in science.

2. There is a concern that science instruction at the elementary school level reflect the nature of science and what is known about how children learn. With existing science instruction being described as lecture/discussion our of a single text, the Search was looking for programs which involved concrete materials and teaching which often took the form of stepping back, asking questions and encouraging appropriate interactions among students as well as between students and materials.

3. Systematic means of changing teacher roles from the didactic to the inquiry would not come easily and Search was looking for on-going inservice of teachers as programs evolved and teachers got support for new skills. In at least two of the programs in this monograph, teachers have a major role in teaching each other how to use materials and trying them with their students, often with a veteran staff member taking a leadership role. Partly because teachers are adding their own touches to the activities and talking with each other about them, programs evolve and a broader owner- ship of the curriculum develops.

4. Especially at the elementary school level, someone has to care about science and that it is taught: someone must work to make others care. Without an advocate who keeps science important, a dynamic program will not survive. Implementation of an appropriate science program takes time, perhaps several years, and consistent advocacy is required. Most of these programs can be traced back to a person or a group of people who gave support, provided resources, and persuaded others that excellent science had a place.

5. In addition to advocacy, a successful elementary science program needs broad-based support among teachers, administrators, and the community. Although it is increasingly difficult for administrators to dictate new programs, no one denies their power to veto or impede programs in which they have no interest. When one teacher was asked why he taught science, he replied, "Because we are supposed to!" It was clear that teaching science was expected by the district and there would be concern if it were not taught. For most of these programs, community support was also evident. When students were asked at one site how their parents might feel if the program would have to be eliminated, students said, "They would be really mad!" and parents told us they would "find a way to keep it going." Community pride in a science program does not come automatically, but it is a powerful force when present.

Summary

It is important to know that there are science programs which match the desired state picture drawn by Synthesis from the science education literature. For those who think that concrete, materials-oriented science won't work, or that science is not a "basic" at the elementary school level, travel to Jefferson County and watch teachers skillfully involving students with materials and ideas; or visit Santa Cruz and watch children working in their garden, or making their own recycled paper; or I suggest, go to any other site described in this monograph. Appropriate science **is** taking place. While the Search has found some exemplars, there are many others. When so many elementary school science programs never got started, did not survive the "back to basics" push, or simply gave up on an active, materials-oriented approach, why have these survived? What are the critical features of these programs which initiated, sustained, and supported their continuing development? This monograph provides a number of answers, many suggestions and ideas, and numerous opportunities for innovation.

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Chapter 2: Project Life Lab

By

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Green Acres Elementary School, one of three schools in the Live Oak School District, is in an unincorporated area of Santa Cruz County next to the city of Santa Cruz. This once rural community of small chicken farms is now the fastest growing area in the county. The largely white population is generally considered to be in the lower half of the socio-economic spectrum but recent building developments, especially condominiums, are attracting a more middle class segment of the population. In 1978 a survey found that 25% of Green Acres' pupils came from families receiving public assistance; the median income in the school district at that time was half that of the county as a whole. At the same time, seventy-five percent of the Green Acres pupils were from homes where they were not living with both of their natural parents and 65% were from single parent families.

Built in the 1960's, our school has 400 students and 14 teachers at the third, fourth and fifth grades. Next to the four-building school is our outdoor classroom, Project Life Lab. This three acre living laboratory for the study of science, nutrition, and gardening includes a solar greenhouse, livestock barn, chicken coop, science museum, pond, earth garden, vegetable and flower beds, and a fruit orchard.

Prior to beginning Life Lab, the school district had no real science program. Individual teachers developed and managed their own programs where, generally, consistency and depth were lacking. In 1978, a survey of the Green Acres teachers found that although all but one of the 15 teachers included science in their curriculum, only 1 in 15 identified "Observation" and the "Scientific Method" as topics included in a science unit. Eight of the 15 teachers felt uncomfortable teaching science due to lack of training and background. Teachers lacked familiarity with science and nutrition concepts, a laboratory area and instructional materials suitable for experimentation, and curriculum materials that were readily useable by teachers uncomfortable with science.

As no program in science was mandated either at the district or school level, teachers had the freedom to choose what to teach and how to teach it. Most often this resulted in students being exposed to very little quality science instruction. A study done in 1977 **(An Assessment of Science Programs in California Elementary Schools,** a Doctoral Thesis by Eugene Brown, University of California, Berkeley) found that California elementary students have an average of less than 45 minutes per week of science instruction.

We also felt the traditional classroom setting with normal academic instruction was not motivating students, especially those from economically disadvantaged backgrounds. Regular classroom instruction was providing only limited opportunities to include active learning such as learning by doing; using all the senses, concrete instead of abstract learning experiences, and real-life problem solving. The classroom, for many pupils, was the scene of prior failures and a tension-provoking environment. Many Green Acres students were having little success acquiring basic skills in regular classroom programs which were not providing opportunities for hands-on, direct experience in practical and applied science. As a result, in September, 1978, 25% of our fifth graders scored in the lowest section of the reading test as did 39% of fourth graders and 26% of third graders. Over one third of all Green Acres pupils were below grade level at the end of that school year.

When we began to see students below grade level in reading we noticed that pupils at Green Acres did not receive a consistent education in science or nutrition concepts or in the study and reference skills that are the foundation of the scientific method. Most of the Green Acres children were unprepared to meet the demands of Junior High School with departmental studies, applied academics, note taking, observation, classification, reference, and study skills. Not only did they lack academic skills to handle a hands-on science curriculum, but also they showed less and less interest in acquiring those skills as they progressed from elementary to Junior High School. A District-wide needs assessment, in which pupils from elementary to Junior High School were polled, showed a steady decline in pupil attitude toward reading, math, self, peers, and the institution of school. For example, in grades 3 through 5, 78% "liked to read books"; while in grades 6 through 9, only 60% "liked to read books". In grades 3 through 5, 65% "felt happy during reading" in grades 6 through 9, only 45% "felt happy during reading". Clearly, something was wrong. A new approach had been needed for years; now they had our attention. We devoted that attention to designing a new, different, and excellent program.

SOME GOALS

We wanted a program where students would **do** science; where they would be involved and active. Our program was inspired by a desire to have students learn through "living" their connections with the world they inhabit. Our own experiences as students in public school classrooms inspired us to improve on the methods and processes of traditional classroom education in a way that was hands-on, outdoors, exciting, and real. We envisioned creating an outdoor laboratory where students could explore, investigate, and discover their world while constantly testing their discoveries. We wanted a balanced variety of topics and an environment capable of being adapted, manipulated, and modified by students in their pursuit of learning. Our vision and inspiration also included indoor labs for more traditional science investigations.

Our broad general goals for students are to have them become active participants in the learning process through the discovery, exploration, and testing of their environment. In addition, we would like to create an awareness in students of their connection to the world they inhabit, and their interdependence with that world. In doing so, they will see their impact on the environment and that they effect much of what happens in their gardens. Many issues, such as pesticide use, famine, and the work ethic are covered; students come to see that much of their future is related to what they, themselves, choose to make of it.

OUR BEGINNINGS

Educational philosophy in this country has evolved to the point where education is viewed as a largely passive process primarily occurring in the classroom using information culled from textbooks. This unbalanced curriculum largely ignores the real needs of the students to participate actively in their learning process. The uniqueness of the project Life Lab Program lies in the placement of students in a learning setting unconfined by walls. The garden as an outdoor classroom/laboratory demands that students take an active role in the educational process. It does not relegate the students to the passive role and the teachers to the active role. We did not want the traditional, unbalanced model.

The transition from an unbalanced indoor program to a balanced indoor/outdoor program was a gradual one. Project Blossom, a CETA funded community organization housed in unused space at Green Acres School, was constructing solar greenhouses for senior citizen and low income homes in the Live Oak area. Their objective was to assist these people in lowering both food and energy costs with the use of the greenhouse. During this program, the principal of Green Acres School, George Buehring, approached Project Blossom staff member Roberta Jaffe to explore the possible construction of a solar greenhouse at Green Acres School. With donated materials, a construction crew from CETA's Youth Employment Service, and revenue sharing funds, in 1978 a greenhouse was built adjacent to a fourth grade classroom.

Following construction of the greenhouse a small school garden project was begun by Roberta Jaffe with George Buerhring's support and the cooperation of a small group of teachers. Involvement was completely voluntary and initially few teachers made use of the opportunity. Those few that participated viewed the process as primarily for recreational gardening purposes. As the program continued, teachers received unexpected results. They found that the garden could be used as an educational tool, both in and out of the classroom. Other teachers witnessed the success of those already participating and slowly joined in. At the completion of that first school year (1978-1979) all but one of the 15 classroom teachers at Green Acres School were using the garden to some degree with their classes.

We saw clearly that our outdoor lab would be more than studying nature: we and our students would garden and learn about science, survival, and society in addition to nutrition, nature, and nurture. Students were to live in their laboratory: Project Life Lab. Based on that interest, application was made to the State Department of Education for funding under Title IV-C to develop a Garden-Based Science and Nutrition Program for the elementary grades. The program, Project Life Lab, was funded at $50,000 for each of two years beginnning July 1, 1979. A three acre site adjacent to the school and including the original greenhouse and small garden was chosen and fenced. That first summer, project staff and CETA youth employment personnel concentrated on site development. The land, once a utility parking lot for the school district, was plowed and water lines were laid throughout. An outdoor classroom was created including the construction of tables and benches. In addition, a shed was built for the storage of tools and other gardening supplies. Allied with this transformation of a vacant lot to an outdoor lab was the development of gardening, science, and nutrition curricula for both outdoor and indoor use.

The past superintendent, while embroiled in a political controversy resulting in his resignation, was supportive of the initial Title IV-C Grant. Because of the controversy, he was unable to support the program in many concrete ways. The succeeding superintendent was totally supportive and demonstrated that commitment in a variety of ways. He took an active role in project management using his skills to further the program's growth and development. He served as a vigorous spokesman for the project in representing the program to school board members, teachers and community members. In addition, he visited the site or spoke with project staff on a daily basis.

Life Lab began field testing its newly drafted curriculum materials in October, 1979 with the classes in Green Acres School. Curriculum continued to be developed, revised, and field tested at Green Acres School through 1980. In 1980, the draft science, gardening, and nutrition curriculum was field tested in three other settings in Santa Cruz County with three different models. At Santa Cruz Gardens Elementary School, a half time coordinator was employed to develop the Life Lab Program with approximately half of the school's classes. At Mountain School,, small and rural with five teachers, a K-2 teacher implemented the program with a small plot of playground land and a budget of only $200. At Salsipuedes, a largely rural, hispanic school, a fourth grade bilingual teacher developed the program with two planter boxes placed on the cement walkway adjacent to her classroom. As a result of the successful implementations at these field test schools, the draft curriculum was published in 1982 as **The Growing Classroom,** a three book set.

During the school years 1979 through 1981 new units were introduced to teachers through monthly one-hour inservices held by Life Lab staff. Teachers were trained in the use of the new lessons and accompanying materials. In addition, Life Lab staff were available to assist teachers with implementation when special problems arose. A curriculum committee of one teacher from each grade and Life Lab Staff met monthly evaluating and revising the prior month's unit during those two school years. Using an evaluation form provided by Life Lab staff, classroom teachers were asked to assess each and every lesson used during those two years.

Now, those teachers who were pre-disposed to teaching science have increased and deepened their programs with the use of Project Life Lab. Others who had been uncomfortable or intimidated by the teaching of science now display an enthusiasm for science teaching. As it has become for the students, science for the teachers is now an exciting hands-on subject grounded in their everyday world; a voluntary program used willingly by all of the teachers at Green Acres School.

Students are actively inquiring into needs of a garden; nutritional requirements of humans; and the value, ethical, and moral questions posed by food and lack of it. Students also consider the cost of seeds, equipment, and labor in realizing the value of their harvest. Some students calculate a fair price for their produce and compare this to supermarket prices. Regardless of the activity, student, or grade level, students see humankind in a central role in solving (and creating) problems of the natural and human-made environment. In using the natural environment in such a positive way, they cannot but help to see relevance and ties to their local community and all communities through their dependence on agriculture. Much of this is because of the success of our inservice.

FRIENDS OF THE HARVEST

As we progressed, community leaders became excited about Project Life Lab as they sought ways to help us. Materials were donated, expertise given, labor provided. From this active community support grew the idea for a non-profit community organization to support us; **Friends of The Harvest** was born. Now that our Title IV-C money is gone, the school district and our Friends of the Harvest provide funding. Friends also provides publicity and dissementation efforts to other schools and districts. Now employing both an education director and a fund raising/community outreach coordinator, Friends of the Harvest has been critical to the program's growth and success. Attracting parents, teachers, business people, university instructors, agricultural people and neighbors, it has served to generate community support for Project Life Lab. This has resulted in heightened visibility in the community providing an array of support from donated lumber to volunteer time to media attention. Friends of the Harvest's primary responsibilities are in the areas of community outreach, fund raising, and dissemination of the program to interested schools. Following publication of **The Growing Classroom** a county-wide dissemination scheme was designed by Friends of the Harvest.

Currently, Friends of the Harvest is disseminating the Life Lab program to ten Santa Cruz County elementary schools. The schools represent a cross section of characteristics found in California Elementary Schools and include a large urban school; a small, three teacher rural school; a largely middle to upper middle class anglo school; a mostly poor hispanic school; and an open school. Ability levels, class size, socio-economic status, and attitudes vary greatly across this spectrum of ten schools adopting the Life Lab Program.

The Life Lab program is based on **The Growing Classroom,** a three book teacher's guide designed by Project Staff divided into three books for easy teacher use: Becoming a Farmer; Science; and Nutrition. **The Growing Classroom** is best used as an integrated program teaching science, nutrition, and gardening in conjunction with each other though the books can be used independently if desired. For example, one may choose to use the nutrition book, foregoing the science and gardening books. Or you may simply use the gardening book and start a class garden. Thus, you can develop a program one step at a time. Book 1, **Becoming a Farmer,** has as its purpose the laying of the ground work necessary for successful implementation of a Life Lab program. Areas addressed include Selecting the proper garden site, preparing the soil, planting and cultivating the harvest, gaining school support, and stimulating community involvement. Curriculum included covers a basic gardening unit and an experimental beds unit. Book 2, **Science,** has students investigating, exploring, discovering, and testing with ten units: Problem Solving/Communication, Soil, Photosynthesis, Interdependence, Energy, Awareness/Discovery, Growing Cycles and Changes, Insects, Flowers and Pollination, and Recycling. Students experience "Scientific Discoveries" through group problem solving, observation, graphing and experiments. Book 3, **Nutrition,** is designed to create greater nutritional awareness among students with the following units: Food Choices, Nutrients, Consumerism, Basic 4, Digestion, and Recipes.

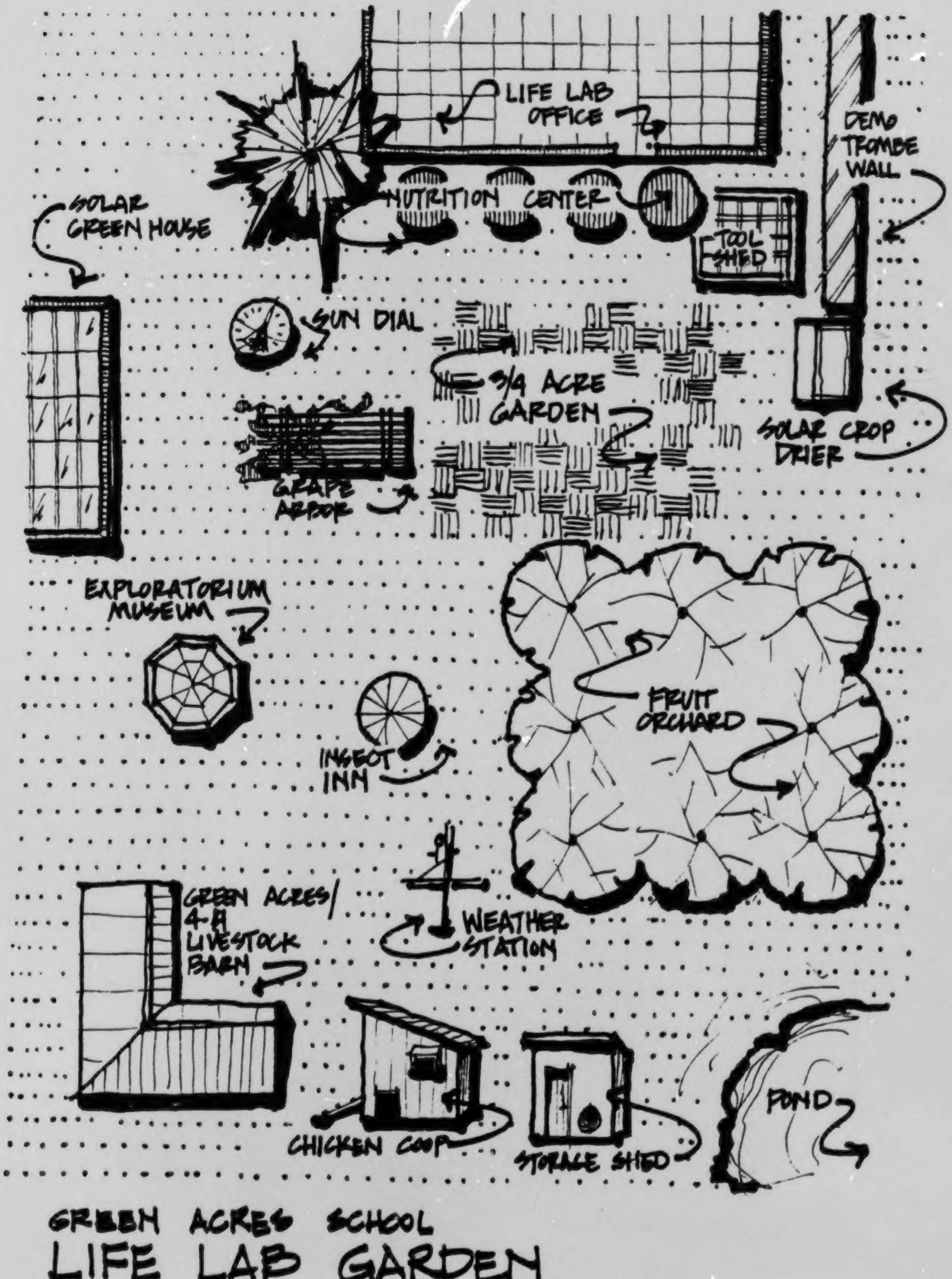
In one unit, for example, a student in the science center may learn the parts of a seed, take a seed apart, and learn how a seed becomes a plant. At the gardening center the student plants seeds after discussing the needs of a growing plant. At the nutrition center students study edible seeds and their nutritional components. They then harvest seeds from a pumpkin, bake them in the solar oven, and eat them.

At Green Acres Life Lab, each class participates in the outdoor program for one hour each week and the indoor program for another hour. As a class enters Project Life Lab, they are divided into three groups or "Centers". Group 1 may be a nutrition center, group 2 may be in a Science Center, while group 3 may be in gardening center. A visitor might find students testing food for protein, carbohydrates, sugar, and vitamin C in the nutrition center. At the science center, the visitor might see students designing their own food pyramid or engaging in a predator-prey exercise. At the garden center one may glimpse students sowing seeds in flats or making compost for their class beds. Should the visitor peek into a classroom, they might find a class occupied with the study of the water cycle or the graphing of their plant's growth for that week.

The uniqueness of the program is based on the interrelated nature of science, nutrition and gardening and its presentation as a cohesive and coherent package. Students are working together cooperatively in a very personal way. They can view themselves an an organism in their environment; an organism which has many needs for survival. Comparisons can be made between students and the plants they are raising. Much as the plants have different needs at different ages, so do our students. Life Lab provides the alternatives necessary to meet these differences. There is not just one trite problem to be solved. Instead, there are many more to be identified and solved than can be accomplished. And, when the work is done, evaluation is meaningful. Students in traditional labs often ask, "Did I do it right?" while in Life Lab they have only to look at their gardens to see the fruits of their labor.

The teachers are responsible for all classroom instruction and use the growing classroom for the bulk of their lessons. A relatively structured course of study is followed in science, gardening, nutrition, and the care of tools. With the outdoor lab format of three concurrent lessons the classroom teacher's role is to serve as the primary instructor of one of those lessons along with two of the Life Lab instructional staff. Instructional strategies include laboratory investigation, observation, application, discussions, demonstrations, audio visual media, reference reading, field exploration, individual and group activities, inquiry, and discovery.

During a five day period a visitor will usually find the teacher and students doing something actively. Some may be double-digging their beds, collecting chicken eggs, or making compost. Others may be transplanting seedlings from the greenhouse, measuring soil temperature, testing food for various nutrients, or studying the carbon dioxide-oxygen exchange of their plants. The outdoor part of the program is so much fun that some teachers avoid doing the classroom component.


LIFE LAB OFFICE
DEMO TROMBE WALL
SOLAR GREEN HOUSE
NUTRITION CENTER
TOOL SHED
SUN DIAL
3/4 ACRE GARDEN
SOLAR CROP DRIER
GRAPE ARBOR
EXPLORATORIUM MUSEUM
FRUIT ORCHARD
INSECT INN
GREEN ACRES/ 4-H LIVESTOCK BARN
WEATHER STATION
CHICKEN COOP
STORAGE SHED
POND

GREEN ACRES SCHOOL
LIFE LAB GARDEN

EVALUATION

No formal evaluation of students is done by classroom teachers other than standarized CTBS and other tests. But, pre and post testing with the Stanford Achievement Test (Science Section) and the Metropolitan Aptitude Test (Science) provide some program evaluation. Students have demonstrated significant gains on standardized tests in many academic areas related to Project Life Lab. In science, students have shown more than a two year grade gain after only one year of the Project Life Lab Program. Reading scores at Green Acres School enjoyed significant gains following the inception of the Life Lab Program. These gains were greater than any made in the history of the school. We would really like to measure changes in self esteem levels by those students involved in the program. It also would be useful to have data on the percentage of life lab students who eventually enroll in science courses at the Junior and Senior High School levels. Also, it would be interesting to assess their success in those classes. We intend to pre and post test students at adopting schools in the area of science with control groups established at those schools. We do no formal evaluation of teachers.

At Green Acres, we have a full-time Life Lab teacher, a half-time science aid, a half-time garden aid, a half-time maintenance aid, and several volunteers. While we could offer an outstanding program without all this help, we would not be able to develop materials, apply for grants, get publicity, disseminate our ideas, or write these articles and chapters. And, we are able to do all this very inexpensively; our cost is only $5.00 per student for materials. Our major budgetary need is for funding to maintain one full time teaching position at Life Lab. An increased budget would allow Life Lab staff to provide additional instructional time to students and development of additional curriculum units.

The principal, as the initiator and supporter of a Life Lab Program in an adopting school is critical to its success. The principal serves to create an environment conducive to the implementation of an innovative educational change in his school. Of utmost importance, the administration supports us through the support of a full-time teaching position at Project Life Lab. The administration could demonstrate greater support with a fuller recognition of the importance of Life Lab to all of the teaching and learning that takes place at Green Acres school rather than simply viewing it as a "Science Program". We feel strongly that Life Lab includes much of relevance to social studies, reading, government, mathematics, physical education, and consumerism. Students can read about plant needs and garden tips, discuss societal issues related to crops, sell their produce, and exercise in the garden. Some teachers make use of the magazine, **Science and Children** and gain support in this way as well. The SESE award has been a major boost for the program as an instrument of validation and another strong source of support.

In the future, efforts will be put into further developing classroom materials and curriculum, bilingual curriculum, a pond curriculum, and a Junior High curriculum. We also plan on integrating the 4-H animal program into the school's instructional program. As the program grows older, we hope to see greater ownership by the classroom teachers themselves. We would like teachers to more fully integrate the lab-based Life Lab curriculum into their classroom programs. Teachers should make full use of the opportunities offered by the outdoor lab facility to their teaching of all subjects.

I would like to see greater ownership by the classroom teachers with less dependence on Life Lab specialists for program facilitation. But, classroom teachers will continue, to a large degree, to depend on Life Lab's staff. Eventually, the program will become more standardized and less experimental in nature. Change will occur at a very slow rate in contrast to the intensive and exciting development period we are now ending. The consequence will be a less exciting place for staff with a greater priority placed on maintenance of the existing program rather than program development. A positive consequence will be the sense of greater ownership by classroom teachers; the single most important aspect assuring Life Labs continued existence. Knowing this, our adoption process is designed to be teacher initiated rather than school board or district mandated. This strengthens that sense of ownership. Also, expanding a classroom to include the outdoors brings with it a renewed enthusiasm for teaching.

If we had our wish, we would schedule 4 to 6 hours per week of Life Lab or Life Lab related studies. We would be able to integrate into any study of the basics a good deal of Life Lab related program. On the other hand, if we wished to cause the failure of the program, we would eliminate the Life Lab teacher position at Green Acres school and require the program to operate with no specialized staff at all.

While this is a complex program any skilled teacher with a need for engaging in constant experimentation will do very well. Teachers don't need much knowledge of gardening to allow children to garden. Teachers do need a high level of trust, however, and a good sense of inquiry along with a willingness to find resources. With this in mind, teachers training workshops were first offered during the spring of 1983 for California teachers. These workshops are the primary vehicle for dissemination of the program and will continue to be offered as an ongoing service to teachers during the fall and spring of each school year. Specific information on availability is available from Friends of the Harvest. We also offer our 400 page teachers guide, **The Growing Classroom**, as a three book set for $33.00 from: Friends of the Harvest, 966 Bostwick Lane, Santa Cruz, California 95062. (For more information on implementation of this program throughout the district, see the NSTA monograph, Centers of Excellence: Portrayals of Six Districts.) An interested school would contact Friends of the Harvest for a custom designed adoption strategy designed for the unique needs of that particular school.

Roberta Jaffe, originator of Life Lab, was of critical importance in her role as innovator. George Buehring, Principal at Green Acres School prior to Life Lab and through the first three years of its development, allowed staff the freedom and gave the support necessary to create and implement an untested, untraditional program. He was willing to take risks in the interests of improving the educational process at his school. Without them, there would be no Life Lab.

Chapter 3: Science Center Program

By

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Anchorage, the largest city in Alaska, is nestled between the Cook Inlet and the Chugach Mountains in the South Central portion of the state. The population of Anchorage numbers close to 200,000 in an area of almost 2,000 square miles. The climate is not extreme regardless of the reputation which Alaska has.

The growing Anchorage School District, with 50 Elementary schools, four Junior High schools, three Senior High Schools, four Junior/Senior High schools, one Career Center, and two Special Education Centers, serves more than 39,000 students; nearly half the student population in the state. Since 1940, the district enrollment has multiplied more than 62 times. We have every imaginable type of student in our system for Anchorage is truly a melting pot of attitudes, abilities, and attributes.

In academic achievement, Anchorage students show high achievement. Anchorage seniors taking the Scholastic Achievement Test in 1981 scored an average 464 verbal and 499 math, 40 points higher than the national verbal average and 33 points higher than the national math average. On the Iowa Tests of Basic Skills Anchorage students were at the 63rd percentile districtwide, 13 points above the national average. These high scores reflect the high caliber of our teachers; sixty-five percent of the 2,000 teachers in the Anchorage school district hold a Masters degree equivalency or higher.

Before 1977, elementary science education in the Anchorage School District was dependent on the abilities, interests, and initiative of individual staff members. In some instances, this meant District students received high quality science education experiences and, in other instances, science education was neglected. Regardless, science education in Anchorage lacked continuity between grades and buildings and science education efforts were, generally, of an unknown quality and quantity. Science education within the District had not been adequately described and we assumed a duplication of cost and effort resulting from the multitude of efforts within the District classrooms and buildings. Additionally, because of the many local efforts to define "the science curriculum," District students were often over-exposed to some concepts while never beginning others. Although teachers had adequate freedom they had no real direction and the curriculum was mixed from hands-on to nothing. We taught in ordinary rooms with ordinary materials and ordinary ideas.

IN THE BEGINNING: SCIENCE CONSULTANTS

The addition of a science consultant gave initial focus to science education and an elementary science curriculum committee began actively identifying needs while the administration gave support. We began planning for a new curriculum in the spring of 1977 and initiated a pilot project that Fall. The planning and pilot program came about after talking to many science coordinators identified through The **The National Science Teachers Association**. We found four science consultants with programs appearing to model aspects of where we would like to be: Joe Premo, Science Coordinator of the Minneapolis School District; Dave Lapp, Science Coordinator, Fairfax, Virginia School District; Charles Hardy, Science Coordinator of Highline School District (Seattle); and Marge Melle, Elementary Science Specialist and Harold Pratt, Science Coordinator, Jefferson County, Colorado shared program ideas and led inservices. By always responding to our many phone calls and letters they gave help all along the way, providing many details of their successful elementary science programs. (A description of the Jefferson County program is found in Chapter 5 of this monograph and in a companion NSTA monograph, **Centers of Excellence: Portrayals of six Districts**).

Key events for us were obtaining Title IV funding and support from the various departments within the school district. This support provided inservice of teachers and allowed us to make materials available to teachers upon request. Dr. Marilyn Scott, presently Assistant Superintendent of the Anchorage School District and Director of Media Services at the time of the grant, was instrumental in writing the first grant, gave space and clerical aid, and in general, was the one person who made it possible. Dr. AnnaBeth Brown, Coordinator of Elementary Curriculum, was very supportive and gave assistance as well. Dr. E. E. (Gene) Davis gave support and direction as Director of Program Development and then later as he moved to Assistant Superintendent and then Superintendent.

OUR GOALS

The Anchorage School District's Elementary Science program was developed before the major criteria for Excellence in Science Education were disseminated. However, as the criteria are reviewed, it is apparent that the Anchorage science program at least touches on all the criteria and has considerable emphasis on four of the areas. We stress:

1. People's effect on the environment and developing custodianship
2. Observation of variation in interpretation of data
3. Experiencing the hard work involved in identifying and resolving problems
4. Great variety of "basic" sciences

For the area, "Recognize people effect on environment and developing custodianship," we have eight units with eleven supplemental units having the same thrust. In the area of "Observe Variation in Interpretation of Data," the largest percentage of our units do have this criterion built in. A prime example would be the student interpretation of Mystery Powders at the third grade level. Teachers are encouraged to work with the students to collect, record, interpret, and communicate data. This is one of the main goals of our elementary science program.

The next criterion, "Experience the hard work involved with identifying and resolving problems," is a long-term goal of our district. Problem identification and solving is a focus of all the discipline areas and in science we have a running start on the challenge as there are built-in problems in the units at each and every grade level.

The Focus on a "Great variety of basic Sciences" has the most emphasis of all the criteria in our program. The Anchorage School District philosophy is that all students should experience science and that all students should have a substantial foundation in the basic areas of science. It is to this aim that the Science Center was developed and the areas to be covered were decided upon. We have endeavored to cover the areas which are necessary for being a scientifically literate citizen. We also stress:

5. Effective consumer behavior
6. Effective personal health practices
7. Recognition of people involved with scientific pursuits

Number 5, "Effective Consumer Behavior," is dealt with, for example, in our fifth grade unit, "Paper and Ice Cubes." Several of the lessons revolve around the decision of which paper towel is the best buy. The students use the scientific method to work through the problem. Two main objectives are learning the rudiments of the scientific method and understanding decision making in relationship to being a consumer.

Number 6, "Effective personal health practices," is not addressed per se in the science curriculum as there is a separate health curriculum for our elementary schools. However, we do have a "Bones" unit which covers the students' skeletal system. Also, there are two "Water" units and the importance of clean water supplies is stressed.

The seventh, "Recognize the people involved with scientific pursuits" is not covered directly either. Teachers have access to a Community Resources program where any number of practicing scientists can be invited into classrooms for presentations. In addition, there is strong support from the community and teachers and students have opportunities to work with people in the science field. These seven criteria are important and will most likely be used when new units are added to the Science Center Program.

We feel scientific literacy is essential for every individual in today's technological society. In all walks of life, constant exposure to the scientific world makes it imperative to educate our citizenry in such a way that they will be able to function at the highest level possible. The overall goal of the Science program in the Anchorage School District is helping our students to:

- * learn
- * appreciate
- * enjoy and use science
- * become scientifically literate.

We want students to:

- * use scientific problem identification and solving
- * use inquiry processes of science
- * use the language, instruments, idieas, and operations of science

- value science as a way of learning
- communicating about self, others, ideas, and natural and technological phenomena.

The goal of human adaptation and alternative futures also is considered in many activities.

During the middle 1970's the Anchorage School District Science Curriculum Development office addressed two problems within the District. The first problem centered about the management of instructional material for the District's elementary science curriculum. The second problem focused on the need to define and articulate the District's science curriculum.

During the post-Sputnik era of the 1960's, the United States was trying to regain the lead in science. At this time, the Nation's leading science educators developed a number of elementary science programs for which a process and hands-on approach to teaching were the key ingredients. This approach was based largely on the work of Jean Piaget who noted that students are often taught abstract theories while they are still in a concrete state of reasoning. Thus, the process approach was designed to provide students with experiences which would help to progress them from concrete concepts to abstract reasoning.

In general, students reacted favorably to the new programs; they became involved with learning. Even though students were enthusiastic about science, all was not well with the programs. As the schools implemented the process oriented programs, three difficulties began to emerge. The first, expense, was not a serious problem. The second, material management, and the third, appropriate teaching strategies were more serious. Many school districts overcame the first problem by applying for and receiving funds under the various federal title programs.

The other difficulties were the more challenging ones. Principals were concerned about keeping track of the multitude of materials and supplies as well as taking care of (and having room to store) the larger commercial kits. Teachers became frustrated when they would try using a kit after someone else had used it and found that part of the kit was missing. The lack of parts and supplies rendered many of the commercial science kits useless. Teachers used to a text-centered curriculum were not always able to use materials based on a specific teacher philosophy and rationale. And, when the materials were not there, it was easier to use the text. Science education within the Anchorage School District was variously conducted depending on the abilities and interests of staff members. In some instances, this meant that District students received high quality science education experiences. In other instances, however, science education was neglected.

In accomodating these problems, District staff members developed two general solutions. In addressing the instructional materials management problem, the staff proposed to develop a District Science Center. The major functions of the Science Center would fall into two categories; repository functions and distributive functions. The repository functions include the acquisition of science education materials and supplies (excluding books) and the acquisition, development, assembly, and refurbishing of science kits for use in classrooms.

The distributive functions included development and implementation of an inventory system, operation of a materials/kit lending program, and implementation of an outreach effort through which Science Center staff members could assist District teachers in the planning and development of science activities and through the demonstration of kits. By the end of the Project, a manual for the establishment and operation of a District Science Center was also produced.

The District proposed to adapt a collection of K-8 science objectives for local use. In particular, the science scope and sequence collection which had been developed by District staff members was to be field tested within the District. In addition to the work with the skills and concept collection, the staff proposed to continue the work of developing and identifying curricular support materials such as textbooks, films, and film strips which are keyed to the science scope and sequence. The final component of the work within this area was to be the development of a science assessment system which reflected the District's science curriculum. Three major tasks to be undertaken within this problem area included final adoption of the K-6 science objectives, ongoing identification/development of curricular material which could be used to support instruction with the K-6 science sequence, and completion of an assessment system detailing student progress within the K-6 science curriculum. I was the director of the Title IV program and I am now the science specialist.

Our Program

Although science education in Anchorage is fairly expensive in terms of time and money, it is taught because, as an important part of American culture and civilization, every citizen should have some appreciation for the influence of science on economic, social, and political problems. Individuals cannot afford to become strangers to the scientific and technological aspects of their culture. It is essential that in addition to the knowledge which has arisen from the scientific enterprise, the science curriculum must also be concerned with the nature of science itself. Hands-on science focuses on the processes involved in the production of scientific knowledge and leads to science literacy and an understanding of science as well as the more traditional knowledge and skills of science.

In our program students are involved in structured science delivered by their own classroom teacher. At each grade level, kindergarten through sixth grade, four to eight units covering three basic areas of science (life science, physical science, and earth science) are available from the Science Center. These units have been made into kits containing teachers' guides and all of the materials necessary to provide children with hands-on science right in their own classrooms. The Science Center approach to providing science materials for elementary classroom use has resulted in efficient use of one hundred different kits available for checkout by elementary classroom teachers. (Other programs described in this **Focus on Excellence** monograph use a kit system as well. See chapters 7, 8, and 11).

The Science Center does more than pass out kits; the center implements and continues the development of the science curriculum. As a focal point for science curriculum implementation, the Science Center is built on the principle of sharing. The most visible evidence of this sharing is the cooperative use of science materials, units, equipment, and supplies which circulate from the Science Center. There is a substantial saving in dollars through the shared use of these materials at the same time. In addition, sharing the material provides for a wider range of units available to teachers and the continued maintenance of teaching materials. This materials system allows for accountability as well as full use of materials. We are sure science materials are in every room and that science is being taught every day.

Beyond these obvious benefits of sharing are more subtle, but equally important, dividends to cooperation. The Science Center Curriculum Committee, with a key role in the operation of the center, has a thorough understanding of the science curriculum including its goals and objectives. Members are constantly involved in the evaluation of curriculum materials while identifying inservice needs and providing feedback from schools regarding the operation of the center. They form an important liaison and resource for the Science Resource Teachers. The Principal's Advisory Committee also provides input for the operation of the Science Center and the identification of a variety of need as felt by the staffs that they represent. These committees are where the action is. It is here that communication between schools takes place, articulation of the science program K-6 is possible, and curriculum is examined and evaluated.

The Resource Teachers have a dual role with regard to the Science Center. Resource Teachers serve as liaison to the Science Curriculum Committee and provide support to the Science Clerks in the operation of the center. The major role of the Resource Teacher, however, is a cooperative teaching function. This role provides service to teachers helping them in planning, teaching, and evaluating their science experiences. This role enhances classroom teachers' insights into science and provides a different person's perspective on a scheduled basis. Science resource teachers also go into the classroom discussing various careers and how science learnings can be applied. Individual teachers also mention careers as appropriate. The Science Resource Teachers play key roles in instruction by taking students on nature walks, presenting special topics, and offering inservice for teachers as well. Our Community Resources Department makes available local speakers from the community and arranges field trips also.

As our science program has expanded, the operation of the center has become increasingly complex. The ordering of kits, for instance, cannot normally be done over the phone. To minimize conflict, clerks recieve orders through the mail at least one week before the desired delivery date. Science kits are then delivered to most schools on a particular day of the week and it is important to be aware of this day so that delivery and return of the kit can be anticipated. The Science Clerks refurbish science kits distributed by the center; checking the condition of equipment and supplies, replacing missing items and caring for living things in the center, such as plants, mealworms, sowbugs, tadpoles, and rabbits.

Clerks also answer questions and refer appropriate questions to a Resource Teacher. Organizing, developing, and implementing a record-keeping system for check-out materials has been another important task for the science clerks. In maintaining kits, science clerks order needed consumable materials and prepare materials for inservice needs. In my mind, having the kits furnished and refurbished on the district level makes all the difference between teachers being involved and not being involved. I know they have the kits and our inservice has assured me they know how to use them. Teachers are much more comfortable in using hands-on science now that they do not have to be concerned with storage, purchasing, or counting materials. They also have someone they can call with their ideas and concerns.

At the first grade level a unit, "Let's Learn About Energy Users," helps students learn about energy and their own future. This unit starts developing a foundation on which students build and then study energy, the environment, and themselves. Grade three offers students ways to investigate electricity, machines, and technology which broaden their understanding of the world. In grade four students investigate insulating materials, learning information and ideas which will help them in making decisions for the future. Grade five emphasizes ecology and helping students prepare to live in the world as it exists now and may exist in the future. Grade six has four major units stressing energy. Two of these are devoted to alternate forms and energy futures. All the energy units are designed to allow students opportunities to make decisions.

Units such as, "Which Paper Towel is the Best?", help in the development of understanding and use of the scientific method and its application to relevant problem identification and solving. Like our whole program, this unit is geared to scientific inquiry and everyday living. Along with inquiry, value, ethical, and moral aspects of science-related issues are discussed with the students throughout the curriculum. Teachers or students bring up issues as they seem relevant. Issues are not provided in the curriculum and teachers or students bring in current issues as they occur.

Teachers are encouraged to relate science to human enterprises wherever they can. Applications of science are stressed along with the nature and processes of science. Science is presented as tentative, inquiry oriented, and a way of explaining natural phenomena. Our curriculum was not designed to be taught as facts. There are problems to be identified and solved and issues to be resolved. Since it is not "fact centered," we have several kits or units which teach the same skills and the teachers are able to select units which best suit their needs and the interests of students at that moment. Also, when skills, ideas, and concepts are repeated in several units, students are more likely to learn them.

The curriculum has been developed, written, and adapted from other science programs and has been carefully reviewed by various science educators. As a result, it is probably as valid as it can be, given that our adaptation was locally produced and implemented. Much of our curriculum includes a local emphasis of the sort that can only occur if we write and adapt our own. When our second grades study birds, they study Anchorage winter birds. In fifth grade, ecology units focus on local ecology, its problems and solutions. We have nature walks at all levels with special curricula designed just for our area. While we don't include all biomes, we make good and relevant use of the one in which we live.

Our locally written material for grades K-6 uses all the **Elementary Science Study (ESS)** and the **Science Curriculum Improvement Study (SCIS)** materials. In addition, we use a variety of supplemental text books including: Harcourt Brace in grades K-6, McGraw Hill in grades 1 and 2, and Addison-Wesley and Holt Rinehart & Winston in grades 3 through 6. Even though we have not stated this directly in the curriculum, the student as an integral part of the cultural and social environment is woven throughout many of the concepts we strive to teach.

In selecting and designing activities we paid close attention to the needs of our students, the nature of science, and what we know about how children learn. We studied the cognitive psychology of Jean Piaget and received training from Dr. Virginia Johnson on learning styles and Dr. Her-man Epstein on cognitive development. Dr. Mary Budd Rowe, Charles Hardy, Harold Pratt, Dr. Harold Jorgensen, Marge Melle, and Laurie Dumdie, taught courses on elementary science to help us understand science and children. We are striving to fit the curriculum to the student rather than the student to the curriculum.

Insight into scientific process is accomplished primarily by means of a wide variety of experience rather than through definitions and names. In this way the intuitive understanding of concepts precedes their precise verbalization. Research indicates that concepts learned in this way can more easily be applied in new situations.

While our science kits generally are designed for two or more students to share materials and ideas, learning centers are stressed in many of the units allowing teachers to give individual attention to students as necessary. But, regardless of who the teachers may be, students are involved actively in doing science. Some teachers select activities for students while others allow considerable student choice. In any case, students use the hands-on kits provided and teachers are now looking at their science teaching strategies. Changes in teaching strategies have caused teachers to think about a philosophy of education and we now feel that we are developing a well thought-out rationale for teaching science.

Elementary students at the primary level receive 150 to 250 minutes of Social Studies, Science and Health each week. Intermediate students have science and health for 150 to 300 minutes each week. If you visited our classrooms you would see students working and learning with our science materials. They will be experimenting, collecting data, interpreting data and making conclusions. Essentially, they will be **doing** science.

The pupil-teacher ratio in elementary grades is 25 to one while at the secondary level it is thirty-two to one. All secondary teachers have a daily planning period while elementary teachers have planning periods scheduled throughout the week. Teachers select units and decide when they will be taught but, since most of the laboratory materials are in the kits, they have little preparation. Sometimes there are solutions which need to be mixed or data sheets to be reproduced. For the most part, though, everything is ready to be used. Teachers facilitate learning actively by involving students in the kit lessons and by providing a respectful learning environment. They may be helping students learn about bones or growing plants or weather or they may be helping students understand the scientific method. Regardless, the good teachers avoid having the students "turn to page 64, read the chapter, and answer the questions." Teachers in our program need enthusiasm, curiosity, and a willingness to try the hand-on approach. Our teachers understand and value an inquiry orientation, use adequate wait time, and respect and accept a broad variety of student answers.

EVALUATION

Rather than stressing scientific knowledge itself, we've tried to incorporate use of scientific knowledge into evaluations of students. Although it is a most difficult task, we do keep trying. We want students to show growth in rational decision making. While our student evaluation does not reflect this as much as we would like, we are working at it. Our Criterion Referenced Tests are based on rational decision making and so far we've gotten good results. While we do not have a standardized science test, our Criterion Referenced Test has been administered randomly to third and sixth graders for the last three years. When our students take the Test of Academic Proficiency at the high school level, they are consistently above national norms. Our District students who have been selected to go to the International Science and Engineering Fair over the years have been achievers and last year two came home with a fourth place in Physics and an honorable mention in Biology. Also, last year we had three students who won the regional NASA space shuttle contest. We collect evaluation data on teachers and kits. Science Resource Teachers are evaluated by principals, teachers, and the science specialist. Our kits have an evaluation sheet and we collect data on the effectiveness of the kits. Through this, we know how many kits each teacher used and how they were distributed by school and grade. Students are evaluated with unit tests and observation of students while they are working. This program is dynamic allowing for change as the need arises. Each unit has a student evaluation instrument at the end of the teacher's guide which the teacher may or may not use. These instruments are based on the unit and are designed to test content and process.

The Science consultant provides for the continued operation of the Science Center, in-service of the Science Clerks and the Resource Teachers, and coordination of the Science Curriculum Committee. As Science Consultant, I facilitate the sharing of information and provide for cooperative purchase of materials. Working with the four Resource Teachers, I provide a general direction for the Science Center model, develop alternatives for presentation to the Science Curriculum Committee, provide long-range planning, and am ultimately responsible for the program.

The Science Center maintains approximately fifty main kits and an equal number of supplementary kits. The chief difference is that specific local lesson plans have been prepared for the main kits while the supplementary kits usually come with only teacher's manuals. Most of the main kits closely resemble kits put together by the Highline School District and the lesson plans acompanying these kits are usually modified versions of the Highline lesson plans. Among the exceptions are most of the kindergarten kits. These kits are based on materials developed by the Science Curriculum Improvement Study (SCIS) group. The lesson plans in these kits are taken from SCIS teacher's manuals. The supplementary kits consist of both ESS and SCIS kits. ESS lesson plans are rather loosely structured and teachers are encouraged to use these kits in a variety of ways. SCIS lesson plans, in contrast, are highly structured and designed to be followed quite closely. Perhaps the most important difference between the ESS and the SCIS kits has to do with their difference in regard to sequential relationship. All ESS kits recommended for any particular grade level may be used in any order while SCIS kits have been designed for use in a definite sequence. That is, the former more or less stand alone, while the latter are conceptually interconnected so that each kit builds upon previous kits. SCIS kits may be checked out for much longer periods of time than the ESS kits.

Each main kit has an inventory sheet which the clerks have checked so that the teacher will know if all materials are in the kits. Each kit also has an evaluation sheet for the teacher to fill our after using the kit. This evaluation sheet enables the clerks and resource teachers to gain feedback and in turn to upgrade the program and materials.

A crucial part of the service is the ability to deliver the actual materials. Provisions must be made to insure the distribution in a timely manner.

Teachers are encouraged to look over the many items on the shelves of the Science Center. These items are often used in some creative way or in experiments suggested by textbooks. Many items can be sent through the regular school mail and the teacher is welcome to come and check these items out personally.

The staff is highly important to the operation of the center. The key person is the Head Clerk who schedules the requested kits, sends reminder notices, orders new materials and is responsible for the smooth operation of the program. It is also highly important that there is enough help to keep the center organized, shelves stocked and the kits in good order.

The Science Resource Teachers' relationship to teachers in the schools makes the difference as to whether schools are willing to try the Science Center program. Where there is a feeling of trust and confidence, teachers will become involved in the process, hands-on type teaching. When the Resource Teacher is perceived as an added burden, then teachers are reluctant to become involved.

Workshops and in-services have been very important for our teacher education. The first NSF workshop, in 1974, was directed by Dr. Harold Jorgenson, Portland State University. It set the tone of the "process" science. From that time-on, much has been done.

Inservice has proven to be a central component of the Science Center program. With more familiarity with the units, teachers feel more comfortable and will use the resources. In-service must be ongoing. Our teachers have learned through in-service education, credit courses, and by working with universities to insure that good science goals are being met.

Finally, the development and implementation of a Science Resource Center takes commitment from all involved. A center cannot operate on its own and be successful, it takes a larger resource of cooperation from all involved.

Support from the top administration is vital to the program's success. The leadership and vision of the school board and the superintendent were key elements in the development of The Science Center. The Anchorage School District's Science Center would not have become functional without the full cooperation of the Elementary Education, the Audio-Visual, the Staff Development, and Curriculum Development Departments. The cooperation is a model of how Divisions and Departments can work together to deliver a quality program.

In addition to furnishing space, a delivery system and personal, a budget must be provided to refurbish the kits and to expand topics. In the Anchorage School Distrit's budget for 1982-83, there is an allocation of $12,000 for supplies. For supplies alone, this comes to approximately $240/school. Once the program is in place, the actual cost of the supplies and materials is nominal. Counting the materials expenses, clerks and resource teachers the cost of our program is approximately $10.00 per student per year.

Parents are not involved as much as we'd like them to be but principals are. The principals are being moved to be instructional leaders for we find that in schools where the principal is very positive toward science, more kits are used than in school where principals are so-so in their commitment. Principals influence teachers through expectations and evaluations.

NSTA was responsible for all communication with outside program contacts and we would not have the program which we have now without **NSTA**. **NSTA** is important to us for journals as well. For example, **Science and Children** is very important. We try to get all our teachers to read it.

At the present, we are trying to improve what we have. The improvement of student achievement has top priority in our district and, therefore, there is a continual effort to upgrade and update our program. With the assistance of our curriculum director, Dr. Ruth Keitz, I'm confident that our program will meet the needs of the students and the community. We need to develop better exams. We struggle along with the rest of the nations' science educators to develop valid process instruments which can be used with large numbers of students. We would like to develop an aviation unit and add more environmental education and resource educational units.

To get more teachers to teach science we need a continued emphasis on science from Science Specialist, Principals, and Resource Teachers. We plan to continue being one of the very best elementary science programs in the nation and maybe even in the world. I hope our program does not evolve into a textbook program where students are turned off by science by the time they leave 6th grade. If we keep the program, our students will achieve well, be positive about science, and will contribute to the scientific community. If we go backwards to the "textbook" approach I predict that we will produce students who are afraid of science and find it dull and boring.

Several of our teachers have received recognition for their work in the program. One of the resource teachers was invited to Halmstad College in Sweden, at their expense, to share our program. Several distinguished Science Educators have written letters to our staff indicating the level of accomplishment which has been made. Designing, developing, implementing, and maintaining our exemplary program has been very hard, taken much time, and been very gratifying. We, our students and our community know it has been a worthwhile effort.

Other key individuals in the development of the science center were:

Dick Blue
AnnaBeth Brown
Robert Christal
Elaine Colony
Steve Daschner
E.E. (Gene) Davis
John Everitt
Don Judd
Ruth Keitz
Milt Madson
Robert Penzenik
John Pepper
Marilynn Scott
Bob Van Slyke
Les Wells
Anne Wieland

Chapter 4: Cornelius Math/Science Academy

By

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J.P. Cornelius Elementary School
Cornelius Math/Science Academy
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The J.P. Cornelius Math/Science Academy is one of one hundred and seventy elementary schools and thirty-seven magnet school programs within the Houston Independent School District. The school is located on a beautiful, heavily wooded six acre plot in the southeast section of Houston, the energy capital of the world and the technological center of the nation. The school is strategically located within eleven miles of the National Aeronautics and Space Administration Lyndon B. Johnson Center, seven miles from the Texas Medical Center and Burke Baker Planetarium, five miles from the largest petro-chemical complex in the world, and 40 miles from the Gulf of Mexico. All of these significant resources are used by Cornelius students in science.

This middle income community has changed significantly from an all white community in 1960 when the school was opened with 850 students to 40% Black, 30% Hispanic, 28% White, and 2% Asian now. Through the years, as the school community became older and more established, the student enrollment began declining until, by 1976, the enrollment was only 350.

In 1976, Cornelius was selected for development as a magnet school and a science coordinator was named. Of the 740 students presently enrolled in grades 1-6 at the Cornelius Math/Science Academy, 350 are voluntary transfer students from 55 other Houston Independent School District schools and 4 suburban school districts in Harris County while 390 are in our attendence area.

In many ways, the Cornelius school community mirrors the rapidly growing city of Houston and Harris County. Every possible socio-economic level of the city is represented within the school and twenty-five percent of the students qualify for free or reduced lunch. An equal number of the students' parents are professionals, such as doctors, dentists, lawyers, college professors, and teachers. The remainder of the students are from blue and white collar families. The mood and atmosphere within the Cornelius school community is one of pride and commitment; a community of middle class Americans who work hard so that their children may have the best educational opportunities available. This commitment is reflected in a student attendance rate of 96% and a parent-teacher conference record of more than 90%.

Cornelius Elementary Magnet School, a two-story brick structure, has 31 regular classroom teachers, a reading specialist, 2 music specialists, 2 physical education specialists, 4 science specialists, a nurse, a counselor, a librarian, five teacher-aides, and a Magnet program coordinator. There is a strong influence of science seen and felt throughout the building. A "hands-on" approach to teaching both science and mathematics is emphasized at all grade levels.

Three classrooms have been converted into well-equipped labs; two for science and one for math. Each lab has a wet sink and cabinet space. A free-standing structure designed as a passive solar greenhouse and learning center has been built on the campus near the main-building. It was built with help from staff and students. Now it is used as an additional lab. The two science labs are used daily by the science teachers with their classes and for science-related activities such as the Botany, Aquarium, and Animal Clubs which daily care for the plants, fish, and animals housed in the classrooms and labs. The students recognize their responsibilities and carry on their duties in a most efficient and independent manner. In addition to a wide variety of specialized science and mathematics materials and equipment in the labs, we have four computers for use by the students as well as a large number of live plants and animals which are cared for by the students.

FROM OLD TO NEW

Our old program was that of a typical elementary school; textbooks in large, self contained classes with science being taught only the minimum amount of time required. In many instances, teachers avoided teaching science completely. The excitement in the science lesson definitely depended on the individual classroom teacher. There were some classrooms with science or math interest centers but, basically, they were probably not very exciting to the students in comparison to the present program. There was no budgeted source for field trips and a very limited amount of supplies and equipment. The teacher had to make a daily schedule, teaching all of the subjects except music. If teachers wanted interest centers, creativity, individualization, or to explore new techniques, they could do so, but rarely did.

Houston Independent School District developed the Magnet School concept to provide specialized programs in various schools throughout the city, providing such a strong program that parents of all races would be willing to send their children, by bus, to receive this quality education. Integration, through the Magnet School plan, has been achieved peacefully in Houston. Cornelius Elementary School, approved to become a magnet school stressing math and science in the fall of 1976, began with three science teachers, two math teachers, and magnet coordinator developing an initial program during the summer of 1976. A curriculum, (mini-units of instruction), and a scope and sequence were developed. One classroom was converted into a science laboratory and materials and equipment were purchased. Nearly six weeks of intensive inservice for teachers provided our training and the development of our units.

In September, 1976, the new program was implemented into the departmentalized program in grades 4, 5, and 6. This was done so specialized science teachers could teach all of the students in science. The following year the program was expanded to include the third grade. In the fall of 1979, grades 1 and 2 were included. Another major change was to increase our science instruction time from 90 minutes weekly to 60 minutes daily and add a staff member so all science could be taught by science specialists. Last year we added another math specialist, a solar energy learning center, a greenhouse, and a teacher-aide to assist the science teachers in the labs or classrooms. The aide assists in gathering and returning materials. Student monitors are usually involved under adult supervision. We feel we now have good support and the resources necessary for an excellent program.

We did not become a Magnet School overnight. We started in 1976 with only 80 Magnet transfer students in addition to our own area students. Our special program was only for math and science in grades 4-6. The following year we added third grade and attracted another 20 students. By the third year we had a 1-6 science/math program with 135 students. By then we were large enough that science teachers only had to teach science. By 1979-80 we had 185 Magnet students and an aide.

The science program at the Cornelius Math/Science Adademy has been developed on the basis of specific philosophies toward teaching, learning, and science education. These philosophies must be accepted as basic by all teachers in the program. Since the teachers themselves have actually developed the program on a continuing basis, they learned to use the program as they developed it. The emphasis on professional growth has been a continual striving for excellence, and has included using any opportunity to improve the program through increasing teacher effectiveness. While teachers have attended inservices and workshops to increase effectiveness and obtain knowledge and information, the key method for teachers to learn to use the program has been the team-teaching concept. The science teachers are a teaching team. They have learned to use the program through team planning under the guidance and direction of Catherine Seay, magnet coordinator, and the building principals, Harold Lennington and Margaret Kilgo.

OUR PROGRAM

The leadership within the Houston Independent School District from the school board to central administration to area administration has made the magnet school concept and program development a top goal and priority through the years. There has been a continuing willingness to approve budget increases for expansion and improvement of the program. Also, the individuals in leadership positions have exhibited a tremendous confidence in the ongoing developments of the program. As a result of the current program, teacher attitudes have changed significantly. Teachers show:

* Increased enthusiasm
* More commitment and involvement
* More positive attitudes
* Increased pride

These significant attitude changes have resulted in higher teacher attendance, an outstanding professional approach to problems, and a cooperative spirit within the school.

There is a range of ability levels among the students within the school. Approximately 70% of the students' performance level now is at or above grade level expectations. Six percent of the students' performance level is one year or more below grade level expectations; the same percentage of students has a special eduation handicap label. The average class size within the total school is 25 students although in the primary science classes there are two science teachers for every 27 students.

The faculty and staff members at the Cornelius Math/Science Academy are very proud of the positive, enthusiastic attitude of the students. The students genuinely like their school and their positiveness toward the school and their enthusiasm for learning is reflected in their outstanding attendance and excellent conduct (75% are A and B conduct students). Visitors to the school consistently comment about how happy the children at Cornelius seem. The teachers take a great deal of pride in the fact that reluctant learners can become eager learners and students with a record of inappropriate conduct can become good citizens at the Cornelius Math/Science Academy.

SOME GOALS

Goals for a program such as the one at Cornelius should be set very high. And, selecting the correct and most stimulating curriculum is of major importance. The idea of Cornelius is not to "try and re-invent the wheel" but rather to help our students learn about science, using high levels of thinking, and then being able to apply these concepts in their own homes, neighborhoods, and lives.

We want our students to learn to appreciate the earth and its atmosphere; to learn much about the world they live in, as well as the animals and plants which share our earth. Ours is an environmental-type science which is applicable to students at home as well as school. We want our students to appreciate and care for their bodies by learning about them through health science instruction. We want our children to recognize the fact that our daily lives are now filled with technology. So, we offer them many opportunities to learn and use a variety of machines. Technology relating to the space program is reviewed often.

We encourage science literacy and hope that some of our students will choose a science-related career as a result of the foundation given in the Cornelius curriculum. The science program at Cornelius is built around the students' understanding and appreciating their environment. As instruction about animals, the universe, forms of energy, oceanography, and plant life is given, there is strong emphasis placed on careers related to each. Cornelius students also participate in many off-campus learning activities where they observe how subject matter is related to real-world experiences. In developing such an understanding, the students develop science literacy and an appreciation of the environment, which affect their thinking in the future.

We relate ecology and neighborhood and community. We stress good use and care of our area in ecology classes; teaching pride in building, campus and homes is part of our goal structure as well. We also stress healthful living and avoiding drugs. Conservation, relating to forms of energy and animal and plant life, is a theme too. Above all, we teach survival techniques where students are taught how to grow and care for plants and grow their own food. But, survival also means being able to survive in a highly technological world. We want our students to understand, use, and care for science so they will be able to survive with quality.

Student learning experiences encourage them to solve personal environmental problems through application of skills taught in science and health classes as well as energy and ecology situations. We teach brainstorming and use questioning strategies to stimulate thinking. Students conduct experiments and learn acceptance and appreciation of persons of different ethnic groups or backgrounds. Students are encouraged to apply the thought processes involved in scientific thinking in their daily lives. Students are given the encouragement and practice to learn the facts before making decisions which will affect themselves as well as others. Our science curriculum relates in-class student experiences to real-world issues. Students are encouraged to discuss and evaluate possible solutions based upon humanistic and moral considerations as well as scientific information.

The science curriculum at Cornelius is problem oriented allowing for alternative strategies in identifying problems and reaching solutions. The diverse ethnic backgrounds found at Cornelius insure the cross-cultural applicability of all lessons. And, the science teachers are flexible in capitalizing on significant world events. Many times, the lessons planned for the day are altered, allowing discussions and observations of science-related current events. This humanistic approach to science teaching stresses the importance of people in decision-making. Throughout the school day, not just in science classes, students are taught to respect one another. Also, as in science, students are taught that certain truths are interpreted differently by people depending on their needs and backgrounds.

Science mini-units of instruction include a wide variety of interesting topics which were originally included in the scope and sequence because of their importance to the Houston community and the future lives of the students. Field trips to enrich a unit of instruction are a part of each unit as well Special projects and reports are in each mini-unit of instruction. Houston is in the center of the petroleum industry, has a world-known medical center; is near the Gulf of Mexico and is within 25 miles of the Johnson Space Center. The planetarium and science museums enrich our topics. Botany, Energy (fossil-fuel, electrical, mechanical, solar) Astronomy, Oceanography, the systems of the Body are taught in all grade levels. Students are involved in clubwork on a daily basis. There is a very active aquarium club, a botany club, an animal club, and a computer club allowing special experiences for our students. If remedial attention is needed there are learning alternatives to offer the students.

We consider the study of the human body essential; as is the study of petroleum, of space, of solar energy, of plants, and of animals because our community is in the heart of the medical center, the oil capital, the space program, and certainly the finest museums and zoological societies are available. Being so close to the coast, we stress oceanography for the same reason.

The students at Cornelius as well as the teachers work as a team throughout the school. If a problem occurs, the students help each other to find a solution. Students and teachers feel the responsibility to contribute in making Cornelius the best school possible. Teachers approach students in such a way that students often feel recognition in decision making. The science teachers function as a team throughout the weekly schedule and, with the staff, work together continuously to help individual students overcome both academic or personal problems.

Science curricula are adapted to the concrete operational learner as defined by Piaget. Classroom interactions are based upon the humanism of Carl Rogers and student needs are recognized within Maslow's hierarchical model. As the students are involved in higher level thinking activities, they are encouraged and guided to apply scientific thinking processes as situations arise in their daily lives. During science and other lessons, decision-making skills are stressed. As students display growth in this area teachers help students recognize growth and to be pleased with the progress made.

One of the activities encouraging this type of growth is the setting up of hypothetical situations which require specific decisions. There is a correlation between social science and science in the development of decision making skills. The teachers in this program are trained to help each and every student find success using one approach or a variety of approaches. It is recognized that a teacher commitment to student achievement is essential to the success of this program.

Since the philosophy at the Cornelius Math/Science Academy focuses on the learner, the students certainly play a very active role in the program. The students have a feeling of ownership in the school; they really know that Cornelius is their school. For example, students are completely responsible for the general care of all plants and animals in the school. Students assist teachers by participating in decision-making, planning activities which can be implemented in instructional periods. However, the teachers do the final lesson planning, evaluation of student learning, and organization of classroom management.

The philosophy at the Cornelius Math/Science Academy is a commitment to the basic belief of the good that exists in all mankind. In numerous ways the philosophy of Carl Rogers is practiced on a daily basis. A meaningful quotation from Rogers places the philosophy of the school and the science program in the proper perspective. According to Rogers,

> "A way must be found to develop, within the educational system as a whole, and in each component, a climate conducive to personal growth; a climate in which the focus is not upon teaching, but on the faciliation of learning. Only thus can we develop the creative individual, who is open to all his experiences; aware of it and accepting it, and continually in the process of changing."

In the Cornelius science program, student-centered teaching strategies are used. In other words, Cornelius teachers use methods which focus on the learner's needs and interests during the teaching-learning situation. They are Rogers' "facilitators of learning", who believe and understand that students will acquire knowledge only when the knowledge has meaning for them, based on their world, inside and outside the classroom.

During any period of time, a visitor would see students in grades 1-6 having science on a regular schedule with lessons generally following the process approach. However, lessons also include much content reading as those skills stressed in formal reading lessons are reinforced using science content. Skills such as finding the main idea, recalling facts, sequencing, distinguishing between factual and non-factual information, and vocabulary skills are stressed. Outside of the formal science instruction, the aquarium, botany, and the animal club members would be in evidence caring for their assigned animals, fish, or plants. Some students would be using the computer located in or near one science lab. During the teaching of each mini-unit, some of the students might be working on a project, a special poster or report, or some special, alternative activities. Students are encouraged when their work is displayed throughout the school and motivated by their teachers to develop pride in their work. Therefore, many bulletin boards and exhibits reflect growing self esteem among individual students.

Science teachers plan their lessons according to the standards set by the district and monitored by the building principal. These lessons must include reading and vocabulary skills using science mini-units compiled by our science teachers. Each teacher is encouraged to be creative and adapt the curriculum to fit the needs of the classes involved so there is some variety in the presentation of materials, using the same concepts. Teachers select the particular topics they desire to teach (from the scope & sequence in use) and contribute suggestions on a daily basis in a team-type situation. Each teacher prepares the laboratory and teaching materials for the classes taught. One teacher-aide is available to assist the team. To facilitate student learning, the science teachers at Cornelius employ numerous teaching strategies which include:

* Motivational Strategies -Motivation and motivating activities are a part of each lesson.

* Strategies which facilitate the development of inquiry skills such as assisting students to identify relevant questions and problems; to collect information efficiently; to summarize and to draw valid conclusions.

* Student-centered teaching methods which include: small group discussions, whole class discussions, oral reporting, whole class debates, symposiums and panels, brainstorming, small group peer teaching, simulation and role-playing.

* Guided discovery strategies in which the teacher presents a specific problem to be solved and provides assistance to students in problem-solving.

During a visit you would see a team of four science teachers and the coordinator meeting the needs of 740 students. The four teachers are on a rotating schedule and three of them teach every child in grades 1-6 for about twelve weeks per rotation. The teachers use the greenhouse/learning center, the classrooms, and off-campus learning experiences. Some of the classes are conducted in the homerooms of the students. The teachers use many different modes of instruction. Models, audio and visual activities, hands-on activities, and other activities provide a variety of experiences.

The specialist science teachers must spend a portion of each day in preparation of materials and in lesson planning. In addition to the regular scheduled classes, the teachers must attend meetings of faculty, cluster, team, and special committees.

The science teachers at Cornelius avoid using the same method of teaching on a daily, weeky, monthly schedule. They avoid busy work even though skills related to written activities are often necessary. The teachers avoid lecturing without interaction from the students and, most of all, they avoid teaching "a science curriculum" in favor of facilitating active participation, learning, and success. Activities are designed with optional choices for the teacher. These activities include hands-on and audio/visual activities, application of reading skills using scientific materials and alternative learning activities to meet the needs of the students. Each mini-unit incudes a special projects page, suggested research topics, a resource page listing the many materials in the building which could be used, and a post-test. The district selected text-book is **Science: Understanding Your Environment:** Silver Burdett. Science textbooks are used as research tools or as science content reading materials. As new materials are purchased, they are incorporated into the mini-units, usually as learner alternatives.

Many other materials are used in our curriculum. Several science publications are purchased on a yearly subscription basis and additional research materials are found in the library and in the science laboratories. Science workbooks are available as are transparencies, study prints, filmstrips, and films ordered from the media center. A microcomputer has recently been installed in one of the science labs. During science, students apply computer skills taught in the math lab. These activities supplement the science lessons, provide additional alternatives for learning, and let the advanced students move ahead more freely. We take many field trips also.

FIELD TRIPS

FIRST GRADE

Burke Baker Planetarium
Arboretum & Memorial Park

SECOND GRADE

Museum of Natural Science
Planetarium Arboretum

THIRD GRADE

Art Museum
Arboretum
Planetarium

FOURTH GRADE

Arboretum
Museum of Natural Science
Sea Arama, Galveston
People Place

FIFTH GRADE

Camp Cullen
People Place
Imperial Sugar
Burke Baker Planetarium

SIXTH GRADE

Johnson Space Center
Planetarium and Museum
People Place
Sea Arama, Galveston

Our curriculum strives for:

* A balance of health, earth, biological, physical science at all grade levels.

* Specific topics for specific grades (petroleum for 6th, oceanography for 4th and 6th etc.)

* Some topics taught on every grade level (solar energy, animals, botany)

* Students being able to enter the program at any time during year without being penalized for not having been in the program beginning with grade one.

* Specific science fair skills and display techniques valuable to students in secondary education and in other subject areas.

In doing this, we cover a broad variety of topics.

TOPICS

GRADE	TOPIC
1	Earth Science, Plants, Matter, The Universe, Health (Teeth, Senses), Animals, Solar Energy, Science Fair Project
2	Coal age plant and Animal, Earth Science Air and water, The Universe Health (Nutrition), Animals, Plants, Weather, Energy, Science Fair Projects
3	The Universe, The earth, Plants, Animals, Energy and Fuels, Ecology, Disease and Health, Science Fair Projects
4	Water, Plants, Health (Bones and Muscles), Marine Biology Wather, Insects, Solar Energy, Magnetism, The Earth, Science Fair Projects,
5	Vertebrates, Invertebrates, Plants, Ecology, Energy and Matter, Rocks and minerals, Machines, Health, (circulation, digestion and Respiration) Science fair projects
6	Astronomy, Embryology, Health (Eyes and ears), Man in Space, Petroleum, Microscopes, Matter, Oceanography, The Atmosphere, Powers of Nature, Science Fair Projects

The mini-units of instruction are designed to allow a great deal of creativity for both teacher and student. New and up-to-date audio-visuals and other materials are added to the program yearly. As more hands-on activities are used in the daily lessons, students are becoming more geared to this type of instruction which is most appealing to students.

We have schedule science so we have time periods long enough for significant investigations.
1st grade - 90 minutes (2 forty-five minute sessions)
2nd grade - 150 minutes (3 fifty minute sessions)
3rd, 4th, & 5th grades - 180 minutes (3 sixty minute sessions)
6th grade - 180 minutes (2 ninety minute sessions)
As Cornelius is a science magnet school, science is treated as a basic subject and an allowance is made to use more time for science instruction. Also a portion of the science instruction is an application of the reading and language arts skills dealt with in a most effective way. Our weekly times are far more than the norm.

EVALUATION

The science program at Cornelius is formally evaluated by the Research Department of the Houston Independent School District. There are four formal audits during each school year. A general goal of the science program is to motivate every child in the school through a strong, high-interest program. Beyond an ungraded evaluation of this type, each mini-unit of instruction includes a post-test which is administered by the teacher. Students are evaluated by their general participation in the science program including classroom activities, off-campus learning activities, and science clubs participation. Each teacher evaluates students on class participation, special projects, research, activities, off-campus learning activities, and a post test. Notebooks are kept by each student and evaluated by the teachers. A profile sheet for each magnet transfer student is maintained by the magnet office and test scores are recorded as well as grades.

Each mini-unit, designed to be taught in 2 or 3 weeks, includes a broad goal for the unit and 1 to 3 specific measurable objectives. Each unit includes a pre-test and instructional processes to correlate with the specific instructional objectives.

The most notable achievement of the students at the Cornelius Math/Science Academy has been in terms of significant academic growth. While the progress of the students in elementary science has not been evaluated on a national norm test, the students' test scores' on the Iowa Test of Basic Skills have consistently increased since the beginning of the program. In fact, Cornelius has been designated as an "OUTSTANDING EDUCATIONAL PROGRESS" school within the Houston Independent School District for the past three years.

There are no scholarships and few awards available for students in elementary science; however, the annual Science Fair at Cornelius has received outstanding recognition. Approximately five hundred students enter projects in the fair. Secondary school and college level science education specialists have repeatedly expressed the opinion that many of the student projects could compete in a high school level science fair.

Teacher evaluation is viewed as a positive, critical element of each teacher's professional growth and development. A team approach between teacher and principal is stressed and all principles, strategies, and phases of clinical supervision are used. Open communication within the team is stressed as all teachers know and understand the expectations for teachers in the program. Every possible precaution is taken to avoid subjective opinions, singular judgements, and assumptions during classroom observations. Science teachers at the Cornelius Math/Science Academy are expected to be committed to the program and the philosophy of the program. They are expected to display enthusiasm and to strive for excellence in their students and themselves. The specific criteria for formal classroom observations and evaluations are the criteria within the teacher effectiveness frameworks of "Time Effectiveness, Motivation, and Production Behavior" developed by Madeline Hunter. Surveys of past graduates from Cornelius could prove useful in program evaluation. Input from middle school teachers about our former students would prove helpful in assessing students' preparation and attitudes toward science. Finally, an on-going process of self-evaluation is most essential for maintenance of a strong program.

SUPPORT

The principal gave great support to exisiting ideas when she came, and has led the magnet science program into a much better scheduling and staffing situation. A true sense of teamwork is felt between the principal and the coordinator and between the regular staff and the magnet staff. This has been one of the greatest strengths of the program. The principal has been available at all times for the magnet coordinator and staff. She has used her leadership role in the building many times to promote an atmosphere which is geared for a successful experience. She is more than an administrator. She is actively involved in the program in numerous ways including: selection and evaluation of teachers; participation in science team long-range planning, including yearly goal-setting; input into scheduling; maintaining support for the program within the school, community, and school district; approval of all expenditures; input into the budget; and reviewing science lesson plans weekly.

Teachers are very carefully screened and selected for the program by the principal and magnet coordinator. The principal first influences the teachers during the interview/selection process. The principal influences the teachers in the program on an ongoing basis by role-modeling the type of behaviors expected of teachers; responding to teacher concerns, suggestions, and problems in a open, sensitive, empathic way; maintaining an open, trusting, professional relationship with the teachers; and staying as informed and knowledgeable about the program as possible.

Providing teachers with inservice has been most effective when conducted on our campus to train (or retrain) a person to function as a team member in relation to the unique type of program found at Cornelius. Many hours are spent with the principal and/or coordinator conducting these on-site in-service conferences, sometimes as a group, sometimes on an individual basis. Specific inservice needs, such as use and care of a computer, implementation of Cornelius objectives and goals, teaching strategies, or dealing with special learners, are conducted on campus each school year.

Teachers should maintain a positive attitude toward teaching all types of children and any changes in the science program at Cornelius should be the result of a need for the good of the students. As long as the science teachers are given opportunities to offer positive input relating to changes, there will be few if any problems in this area. It has been of great importance to select teachers with a strong science background. However, Cornelius science teachers must be strong language arts teachers also as the program treats science content reading and vocabulary building skills with utmost importance. It is very necessary for the teachers to have a varied grade level experience as all levels are taught. A teacher beginning in the program at Cornelius should possess a deep desire to teach and work with children, and, most of all, should have a positive attitude regarding self and the program. It would be desirable for a beginning teacher to possess the skills of scientific process as well as the background knowledge. However, given a teacher with a good attitude and a keen desire to succeed, knowledge of the program's concepts could be learned. A new teacher should possess the attitude of learning the program before trying to change it.

The Cornelius science staff recognizes and uses the support materials provided by **NSTA, NABT, AAPT** and other professional organizations. The Houston area science teachers organization brings the Cornelius science staff in contact with these materials through workshops, guest speakers, and field trips. Monthly publications of professional journals such as **Science and Children, Science 83, Scientific American,** and others are available for the teachers to read and use in the development of their lessons and mini-units.

A teacher's aide prepares duplicated activities, grades papers, and gathers materials for teachers daily. Our clerk, who serves as a secretary to the magnet coordinator, often serves as an interpreter and does general secretarial duties. These two support persons extend themselves graciously to meet any and all demands of them.

Support of parents in the community is in evidence in the school daily. There is a generally good rapport with the parents and an awareness of individual needs is maintained. The program was designed for students of all races to find success and, although Cornelius is a minority school, there have been few if any problems in adapting or amending the program to meet community changes. Parents volunteer or are invited to go on field trips to assist teachers, serve as room mothers, suggest guest speakers, keep animals on week-ends and holidays, and maintain the bookstore providing school supplies.

SOME NEEDS

While we have a good program we could use some physical improvements. We need tables or cabinets with sinks, running water, electrical and gas connections. Portable petitions would allow more space for combining two groups for resources speakers or team teaching. Carpeted study areas with tables for group study would be a real asset also outdoor tables and benches would provide extra student work/study area adjacent to the Outdoor Learning Center.

What we would really like is an entire pod for math and science instruction. The core of the pod would house the materials and Resource Center while seven rooms around the core would provide four science labs, two math labs, and a solar learning center.

The planning process would be greatly enhanced if more time for collaborative planning were provided. All members of the science team have imput into the program but there is not enough time for this to be as effective as it could be. More experimental, hands-on activities stressing the scientific processes could then be implemented. Video cassette recorders and equipment would be useful in producing training films for use by the animal, aquarium, and botany Club members. This equipment would also be extremely helpful in instructing students in science fair project procedures and general laboratory experiences. The use of microcomputers in each science laboratory would lend itself for initial instruction, learner alternatives, and special programs to complement the presently used mini-units of instruction.

There is a strong need for additional aides and possibly an additional science teacher. The problem of staffing could be solved immediately if an increased budget were possible. The teacher-aide could support the science teachers; the additional science teacher would relieve the magnet coordinator of a heavy teaching load which has been necessary for scheduling classes in the manner we have found effective.

One particular programmatic change that would be helpful in the total success of the program would be for each science teacher to specialize in specific science areas and develop the units and materials in that area in a more sequential order from grades one through six. A more sequentially developed set of objectives would update the presently used mini-units. This would enhance reinforcement of concepts but help avoid too much repetition. A stronger emphasis on science process skills incorporated into mini-units would lead to a greater number of meaningful hands-on experiences.

Because the students have responded so positively to the science program at Cornelius, there will probably be few immediate changes. We hope to become a model school for other schools in this district and others. Children enjoy science and students come to Cornelius with a varied background and varied attitudes toward learning. Many students unsuccessful in other situations have been very happy and successful here. It would be good to have the students receive science on a daily basis as activities which are on-going could be better handled. Sometimes, the day "skipped" causes a learning barrier for both the teacher and the student. The amount of time would vary from grade level to grade level.

If we wanted to make our program fail, we would:

* Put science teachers back into classrooms with homeroom duties
* Make science strictly a textbook program
* Dismantle science labs
* Discontinue field trips
* Become incompetent, uncooperative teachers

The rewards of an excellent science program are indeed great. Cornelius teachers are motivated to be creative, each teaching in their own style with an excellent opportunity to promote student achievement in varied ways; to develop a better understanding and appreciation for science. Each teacher is proud to be a part of a successful operation where people can work together, forming strong unions for the betterment of each other and those around them.

Many individuals have made significant contributions to the science program at Cornelius. The magnet coordinator, Catherine Seay, has supervised the program on a daily basis since its inception in 1976. She has provided strong leadership, outstanding professionalism, and an ongoing consistency to the program. Her love for children and commitment to science education is an inspiration to all who know her.

During the first two years of the program, the science teachers were Virginia Hayes, Gerald Reid, Barbara Wojdyla, and Jeanene Steffen. Under the leadership of Dr. Harold Lennington, Cornelius principal during those years these teachers wrote the original curriculum in the form of mini-units. At the present time, the science teachers, in addition to Elizabeth Smith, are Sandra Schnurr, JoAnna Harrison, and Rhelda Ball. As each of these individuals joined the team, they have contributed in their own special talented ways to making the ongoing development of the science program and curriculum unique and innovative.

In the 1978-79 school year, Elizabeth Smith joined the staff as a primary science teacher and subsequently wrote the primary science units. Margaret Kilgo is the current Cornelius principal, a position she has held since 1978. Under Mrs. Kilgo's leadership the program has improved and changed in a number of ways. Her greatest contributions was reorganization of the program so science teachers were primarily responsible for the teaching of science. All homeroom and other subject area teaching duties were eliminated from the science teachers' role description in 1979. She also stabilized the entire school staff and implemented many positive student incentive programs to give the school a real spirit.

Billy R. Reagan, General Superintendent of the Houston Independent School District since 1974, originated and implemented the Magnet School concept in the Houston school district. He has provided tremendous, support to the Magnet Schools. Faye Bryant, Associate Superintendent for Magnet Schools, has provided inspiration and total support to the program since its inception. She actively supports all changes, including budget increases, which she believes will improve the effectiveness of the program.

Arthur M. Gaines, Deputy Superintendent, has given the science program his complete support from the beginning. Joyce Shepherd, Associate Superintendent, Area IV, has provided motivation and her complete support through the years. Dr. Carolyn Sumner, curator of the Burke Baker Planetarium, has been an invaluable asset to the program. In a consultant role, Dr. Sumner has provided outstanding guidance in the science curriculum. In addition, she has actively taught numerous science lessons to Cornelius students through the years. Having Dr. Sumner as a teacher has been exiciting and beneficial to Cornelius students, as Dr. Sumner also teaches space geography to astronauts in the space shuttle program.

The faculty and staff members, students, and parents have also made significant contributions to the science program. Their enthusiasm for the program and support of the program have been the real key to the success of the program. We have no doubt that it will continue and continue strongly.

Chapter 5: Coping and Cognitive Skills in Science

By

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Greenville, the county seat, has a population of about 37,000. Pitt County is predominantly rural, with tobacco being the largest money crop. Greenville is the home of East Carolina University, third largest institution of higher learning in North Carolina, and Pitt Community College. Major industries in Pitt County include Burroughs Wellcome, Eaton, Procter and Gamble, TRW and Union Carbide. Pitt County continues to experience steady and organized growth.

The Greenville City Schools system has a student population of approximately 5,000 in four primary schools (K-3), two upper elementary schools (4-6), one middle school (7), one junior high school (8-9), one senior high school (10-12) and one alternative school. Our science program is being used by thirty teachers, primarily in grades 4-6 by most regular education teachers and some special education teachers.

OUR BEGINNINGS

The idea for a new science program grew first out of an expressed need by teachers in the Greenville City Schools for both curriculum materials and instructional techniques that would allow mentally and emotionally handicapped and learning disabled children to be mainstreamed into the regular classroom. The idea found ready support through ESEA Title IV-C funds primarily because the problem of providing "full and appropriate services" for all handicapped children is faced by all school systems in this country. A survey of the programs available for developing coping and cognitive skills of handicapped children revealed only one program - and no programs appropriate either for mainstreamed students or large-sized classes. Regular classroom teachers' training for effectively managing and instructing heterogeneous classes with mainstreamed handicapped children is generally lacking.

Beyond the expressed needs addressed by this project is the implicit need for providing meaningful science experiences for all elementary-school children that will both develop the same skills defined for the target population (and appropriate for all children) and promote a positive attitude toward science. In fact, although this program was designed specifically to meet a local need, any school system could use effectively the program because of its explicit structure and great flexibility, affording even teachers with no science training an instructional program which is enjoyable and easy to implement, yet one which meets the needs of all students.

Initial planning for this project began in 1978, one year before actual funding. Ann Harrison, the Director of Pupil Personnel and Exceptional Child Services for the Greenville City Schools, developed the initial proposal for the project. The proposal grew out of numerous meetings with university and state education agency personnel: Dr. John Richards, Chairman of Special Education; Dr. Floyd Mattheis, Chairman of Science Education (both at East Carolina University). North Carolina Public Instruction consultants, Lloyd Wimberly, Exceptional Child; and Grace Drain and Donn Dieter, both formerly in the Division of Development gave input as well. These individuals collected data on areas of need and did the preliminary research on available resources.

Development of the science curriculum began in 1979 when the Greenville City Schools was awarded an ESEA Title IV-C grant of $56,000 per year for three years by the State Department of Public Instruction. This project was to design curriculum materials and identify teacher intervention and instructional strategies that in combination would improve the coping and cognitive skills of handicapped children grades 4-7, thereby enabling the children to function more effectively both in school and in society in general.

Throughout the first year of the project, the staff and teachers struggled to mesh theory and practice. The curriculum that evolved is so much a function of this effort that the rationale and theoretical framework for the program must be understood in order to fully understand the structure of the curriculum.

THE RATIONALE

Handicapped children demonstrate a broad range of unique learning problems. Emotionally handicapped children display a variety of behaviors that seriously interfere with learning. Learning disabled and educable mentally handicapped children, because of their educational disabilities, often also demonstrate negative behaviors that serve to compound their learning problems.

Teachers must develop strategies for dealing with these problem behaviors. Many behavior modification techniques that superficially control such behaviors have been effectively used in classrooms, but often do not result in permanent and generalized change, primarily because strategies useable in a classroom setting must focus on quickly eliminating the overt behavior. Therapy and counseling, on the other hand, strive to identify, or at least resolve, the psychological conflicts that cause the overt behavior. These methods deal primarily with the affective domain, although current research supports a movement toward cognitive control training (Hallahan).

Our program focuses on promoting permanent changes in behavior through the remediation of deficiencies in certain cognitive functions. However, since a long-term intervention is required to develop cognitive skills, the curriculum also does promote the use of positive behavior management techniques to use as an interim strategy.

The rationale supporting the remediation of cognitive skills as a route to improving behavior is based on the assumption that a child's inappropriate behavior in the classroom is a reflection of his/her inability to cope in general. This inability to cope may be the result of deficiencies in certain cognitive processes.

For example, one cognitive deficiency prevalent among emotionally handicapped children is the inability to engage in hypothetical thinking, that is, the consideration of consequences (being able to figure out "what would happen if..."). Obviously, a child who does not engage in hypothetical thinking would not be able to consider the consequences of misbehavior. As a second example, consider the problems of an emotionally handicapped child who has an episodic grasp of reality. This type of child, who perceives each experience as unique and isolated, lacks the ability to perceive relationships among events and objects, to compare, to categorize, or to recognize cause and effect relationships. The child may be "managed" in the classroom by structuring his/her environment and restricting freedom, but will never truly learn to cope until she/he develops those cognitive skills that enable one to learn from past experiences.

In addition to directly changing behavior, the development of a child's cognitive functions should also result in an improved ability to perform academically. Improved academic achievement may lead to improved behavior in the classroom.

In summary, the goal of this program is to use the discipline of science to improve learning ability and to alter behavior in children through the development of certain cognitive functions, because the deficiencies in these skills may be the cause of the inappropriate behavior and general inability of the individual to cope successfully both in school and in the community. It is expected that the behavioral changes effected in this manner, although they may require a long-term intervention, will be permanent.

A THEORETICAL FRAMEWORK

There are three components to the theoretical framework of this curriculum: the nature of the science discipline itself, the research concerning the most effective strategies for developing cognitive skills, and the accepted instructional techniques that take into acount the nature of psychological development. These three components have been used to develop a curriculum that accommodates both mildly mentally and emotionally handicapped children and which can be used with either a homogeneous or a heterogeneous group of children.

The nature of the science discipline makes it an ideal medium for developing cognitive skills. A child's interest and attention are readily captured when allowed to explore the environment and manipulate objects. Also, concepts are more likely understood when presented through stimulating concrete experiences. Since science activities are naturally multisensory, the child with sensory deficits can be maximally stimulated and can have opportunities to develop the use of all the senses. Finally, the process skills, or methods utilized by the scientist, correlate nicely with the cognitive skills described by developmental psychologists.

Strategies for the development of cognitive skills have been described by many educators and psychologists. Developmental psychologists such as Reuven Feurstein (Towery), Jean Piaget, and Jerome Bruner (Karplus, et. al.) have shown that cognitive skills can be developed in all children through direct exposure to external stimuli and interaction with one's environment. However, direct experiences alone do not necessarily result in learning. The learner must process the experiences through reflection and discussion, and this requires mediation by an adult who can provide the structure necesary for learning to take place.

Thus the role of the teacher is best defined as a mediator of the learning process who focuses the child's attention and affects the way the child perceives and reacts to stimuli. Piaget has shown that giving a child the right answer over and over does not assure learning. Children must be allowed to correct their own misunderstandings through manipulation and exploration of their environment. The teacher can help, however, by asking the child why she/he responded or acted incorrectly and by directing the child's further inquiry. It is also necessary for the teacher to accept a child's inability to master a concept, process or operation if it requires certain cognitive skills not yet mastered by the child. Such as the ability to classify which requires skill in comparing and contrasting.

The nature of psychological development has been defined in various ways. Piaget's levels of development are possibly the most well-known model. Even children of average intelligence who are in the age group using this science curriculum would still be primarily concrete thinkers. Thus the manipulative and experiential aspect of the curriculum assures the children success and serves to promote the development of reasoning skills leading toward formal thought.

A second model describing psychological development has been introduced by Frank Hewett, creator of the "engineered classroom." Hewett's educational model combines both instructional techniques and behavior modification theory and helps one better understand the unique learning problems of educationally handicapped children. According to Hewett, a child progresses through seven developmental levels and cannot be expected to achieve academically without functioning at the highest (Achievement) level. Also, a child may be functioning at the highest level one day and regress to a lower level another day. The teacher's task is to identify the level the child is operating on and assign appropriate tasks to meet the child's immediate educational needs. This science curriculum has developed activities on three of Hewett's levels: order, exploratory and achievement.

Mentally and emotionally handicapped children require specially adapted instructional and behavior management techniques that take into account both their unique learning problems and their unique behavioral problems. Utilizing the science discipline and current theories of psychological development, this science curriculum has been designed to develop both the cognitive and coping skills of handicapped children.

THE PROGRAM

The two elementary schools in which the curriculum is being used are similar in size, but completely different with regard to the physical plant. Both schools have about 18 classroom teachers, a total of 30 professional personnel and approximately 500 students. Wahl-Coates School is the newer of the two and has a modular, modern design. South Greenville School is 30 years old and is more traditional in its design.

The instructional program is basically the same in both schools. Students are grouped heterogeneously in self-contained classes and are ability grouped within these classes only for language arts and math instruction. Science is taught an average of 100-150 minutes per week. The Holt Series is currently the basal text for science in grades 4-6.

This science program is also being used with severly emotionally handicapped children attending Project CARE, housed in Agnes Fullilove, the alternative school. Students in this program are referred from the junior high schools in both the Greenville and Pitt County School System. This adapted science curriculum enables both regular and special education teachers to develop cognitive and coping skills in educable mentally handicapped (EMH), learning disabled (LD), and emotionally handicapped children (EM) in grades 4-8, while providing a science program that can meet the individual needs and interests of all the children in the class. The curriculum currently consists of a collection of 10 Science Activity Kits (SAK's), each concerned with a different topic in science and requiring from four to eight weeks to present depending on the module itself, the students' abilities, and the frequency of instruction. Although the program was specifically designed for use in heterogeneous classes in grades 4-6, with class size ranging from 26-33 students, the program has also been successful in cross-categorical (EMH, EH, LD) and EMH block resource classes in grades 4-8 and in homogeneously grouped classes in grades 4-6.

Our primary goal is promoting skills and attitudes such as:

* Communication skills
* Socialization skills
* An internal locus of control (independence)
* Precision and accuracy
* The ability to follow directions
* The restraint of impulsive behavior

We also want to enhance student's ability to:

* Effectively use senses
* Compare and contrast
* Categorize
* Recognize cause and effect relationships
* Plan
* Make predictions based on facts
* Hypothesize
* Use logic to prove things
* Organize and interpret data
* Apply information or experiences to new situations

In doing this, our curriuclum is characterized by an emphasis on problem-solving. Although each unit of instruction features a specific topic as its central theme, the dissemination of knowledge plays a supporting role. The fundamental structure of the curriculum is a series of activities designed to provide the students with opportunities to discover, to generate their own information, to interact with each other in a supportive manner, and especially to think. The activities are multi-sensory, multi-level and hands-on. There are activities designed to be used by a single student, by a pair of students, by small groups and occasionally by the entire class. Each teacher determines the extent to which the textbook and other supplementary materials will be used.

At this time, we use 10 SAK's:

Habitats - a minimodule to introduce "Claws or "Isopods"
Current Events - on electricity and magnetism
Claws - on behavior of crayfish
Don't Be Senseless - on the use of the human senses
The Mechanical Advantage - on simple and compound machines
Isopod Investigations - on small animal behavior and experimental design
Close Encounter - on the use of microscope
You Are What You Eat - on digestion and nutrition
Heart and Lungs - on the functions of human circulatory and respiratory systems
The Light Fantastic - on the properties and uses of light

There is no required sequence for teaching modules in this program. The SAKs can be taught in any order and at any grade level from grades four through six. Basic skills and vocabulary are introduced in each module and teachers select modules according to the topics covered in the science textbook. The SAK's were intentionally created in this manner for two reasons. First, the various textbook series available for adoption every five years frequently offer the topics at different grade levels. Second, costs for materials and equipment can be kept to a minimum if teachers share kits by scheduling the topics to be taught at different times of the year.

Although the SAK's are nonsequential, they are not intended to be taught totally independent of each other. Teachers continually interrelate the modules as they teach because the basic vocabulary and the nature of the problem-solving activities are essentially the same throughout the curriculum. For example, such terminology as "predict," "hypothesis," and "experiment," are used in all the SAK's. Likewise, scientific procedures such as observing carefully, planning, collecting data, controlling variables, analyzing and interpreting are also the mainstay of all the modules.

Each SAK is divided into "lessons" that usually must be taught in a definite sequence. The basis for a lesson is a subtopic. Each lesson is divided into "exercises" that must be taught in a definite sequence. A unique feature of this program is that most of the exercises are provided on three ability levels.

The Achievement Level is the foundation for the curriculum. All children are expected to participate in this activity whenever possible. Although cognitive skills are emphasized as the teacher follows the "Lesson Development" plans provided, scientific concepts are also learned. Each lesson includes a "coping discussion" to be used at the end, or at other appropriate times, that applies the concepts or processes used and learned to real-life situations. This discussion may also be used to expand on the use of vocabulary in the lesson and to clarify values.

The Order Level activities, adapted for the low functioning child, are designed to improve reading skills and the child's ability to follow a series of instructions and to increase time on task. The exercises are very brief, highly structured, provide definite closure and do not necessarily address the concepts. The worksheets are reproduced on illustrated language master cards and the materials are boxed separately for each lesson. These activities can be used in various ways: in place of the class activity if the child is having an especially difficult time either academically or socially, if the child was absent and missed part of the Achievement Level activity, as a supplement to the Achievement Level to reinforce parts of the lesson, as a reward for students who have earned special privileges, or even as a preliminary activity for the entire class if the teacher anticipates all the children will have difficulty with the Achievement Level. The Order Level exercises are usually performed individually at a learning center. The exercises parallel the achievement activities to the extent that the same materials and equipment are manipulated. Therefore a child who is having trouble coping within the social or academic structure of the Achievement Level activity can be readily reassigned to this independent task.

The Exploratory Level activities are designed to challenge the average or above average performing child. The use of these activities basically parallels those of the Order Level. Some of the activities correspond directly to the lesson and may be used to promote independent work or provide an alternative for the child who is having trouble coping within the social structure of the Achievement Level activity. Other activities introduce additional variables and complexities for students who are capable of a more extensive and complex study or who demonstrate high interest in the particular lesson. A quick look at the worksheet will indicate which students might benefit from the activity. The teacher may also use some of the Exploratory activites with the entire class or a certain group of students.

Another salient feature of this program is attention to classroom and behavior management that will enhance the learning environment and the development of students' coping skills. Although none of the management techniques is totally unique and the teachers are not limited to using those techniques recommended, the emphasis on the management techniques as a component of the instructional program is unique.

Although several recommended management techniques have been compiled in the **Teacher's Handbook,** many of the strategies are actually built into the lessons. For example, the lesson plans provide instructions on when to distribute and collect equipment and supplies for each activity, thereby eliminating a major distraction or possible misuse of equipment. Possibly the most significant managment technique is the provision of the three ability levels for each lesson, enabling the teacher to have maximum flexibility for the most appropriate assignment of tasks and grouping of children.

Even the packaging of the curriculum has been guided by the needs of the teachers using the program. Teachers in self-contained classes are responsible for the entire academic program and do not have time to assemble all the equipment and supplies required for a hands-on science program. Therefore, all the materials required for each module have been assembled and maintained in one box. Each box includes:

- **Teacher's** Manual
- **Illustration** or Language Master Cards for the Order Level Activities
- **Filmstrips** or other audio-visual aids used exclusively in the module
- **Transparencies** for all Achievement Level worksheets
- **Laminated Sentence Strips** for vocabulary definitions and concepts
- **Laminated Visual Aids**
- **Materials** and equipment for performing the activities
- **Separately boxed material** for the Order and Exploratory Level activities (for the science center)
- **File caddy** for the science center worksheets
- **Trays**
- **Inventory list**

A teacher's manual has been developed for each SAK. The manuals also reflect this need to streamline the planning effort for the teachers. The manual for each module is divided into 5 sections: **Preliminaries, Evaluation, Lessons, Appendix and Reordering Information.**

The Preliminaries section summarizes the academic scope of the unit. Included is an abstract of the unit, a listing of the cognitive skills on which the teacher will focus, and the vocabulary and major concepts to be learned. Important information is also provided concerning the technical aspects of implementing the lesson. A materials list is provided indicating the quantities of equipment and supplies required for each lesson. Materials are categorized according to those needed by each student, by each group, by the teacher and for the learning center activities. Bulletin board ideas are also suggested.

The **Evaluation** section contains a pre/post test for the module. A student progress chart is also included to assist in the monitoring and evaluation of students who may be completing tasks on more than one ability level. A copy of this chart would be included in each student's notebook so the teacher can check beside each lesson whether the child completed the Order, Exploratory, Achievement and/or Supplementary activities.

The **Lessons** section contains the lesson plans. Over the years, this section has evolved from a brief sketch of intended goals and suggested activities to a detailed "Lesson Development" consisting of questions to ask; anticipated student responses; and directions for introducing, managing, and discussing the oucomes of each exercise. "Coping questions" are provided for promoting applications of the concepts processes, skills and vocabulary to all aspects of the students' lives.

An overview of the lesson is provided for each of the three ability levels. This enables teachers to determine quickly the nature of the lesson, the estimated duration, cognitive skills emphasized, performance objectives, supplies for each exercise, evaluation criteria and any special instructions for preparing or implementing the lesson.

Worksheets are included with most lessons. The worksheets are designed to develop communication skills and foster the habit of recording and evaluating data. Since worksheets are provided on three ability levels, even low functioning students can record their own data.

At the end of each lesson is an Evaluation Report form for documenting the extent to which each student has met the performance objectives. The criteria are included on the form for each ability level. This form enables the teacher to easily generate a grade that accurately reflects performance. Grading, usually a difficult task in a process-centered curriculum, becomes realistic and objective when this report form is used.

The **Appendix** contains supporting materials. A vocabulary list has spaces for students to write the definitions. Each student keeps this list in a notebook, adding definitions as new words are introduced in the lessons. The Supplementary Activities and Project Ideas allow the teacher to expand and reinforce skills and concepts as well as stimulate interest. The list of projects includes field trips and suggested community resources. Patterns for cut-outs used in some exercises are also placed in the Appendix.

The final section in each teacher's manual contains ordering information for replacing equipment and replenishing supplies. For convenience, vendors are suggested and catalog numbers provided.

No matter how much efficiency is provided through careful packaging of a program, the effectiveness of the program is always directly dependent on the expertise of the teacher. Therefore, the single most important component of this program is the teacher. Not only must teachers be responsible for determining the most effective use of the learning center activities, they must also provide the instructional mediation that promotes the development of the cognitive functions. Very little intellectual growth can be expected without appropriate teaching techniques.

There are three ways that this program assists teachers in providing the quality instruction essential for meeting the goals of the program. The most direct assistance is the structured lesson plan provided. The guided dialogue, the activities, and the accompanying worksheets are all designed to promote cognitive development. A second assist is the Teacher's Handbook which describes many of the instructional techniques that are universally accepted as effective for developing thinking skills. Finally, teachers have access to a small library of video tapes prepared during the development and fieldtesting of the SAK's by both regular and special education teachers in the Greenville City Schools. The tapes exemplify outstanding instructional and management techniques.

THE PROJECT

Translating our theories into a science curriculum involved a series of modifications and compromises that gradually resulted in a "model" which could be used to develop lessons on any topic in elementary science. The Project Director, Wende Allen, contracted with Dr. John Richards and Dr. Floyd Mattheis at East Carolina University to assist in designing the curriculum. By the end of the first year, a part-time team had been established: Nelda Highsmith, Curriculum Specialist; Mary Roscoe, Technical Assistant, and Debbie Whichard, Illustrator. For three years, Exceptional Child teachers piloted, assisted during the summers in the writing and rewriting, and provided the expertise for identifying intervention and instructional techniques appropriate for the handicapped population being served.

The project staff and fieldtest teachers participated in workshops to develop understanding and skills in working with children with special learning and behavior problems. One of these workshops had a significant influence on curriculum design: "Science and the Development of Reasoning". (For a description of another program which began with the karplus workshop on "Development of Reasoning," see Focus on Excellence Vol. 1 (1), Chapter 5 by Lois Durso).

the topics for the curriculum originated from the Holt science textbook, but the activities were the outgrowth of research that included as resources all the available elementary science textbooks, various special programs (SCIS, SAPA, ESS, HAP, SAVI), an assortment of activity books, and frequent brainstorming sessions among project staff and teachers.

Throughout the three years of curriculum development, all activities were initially piloted by Special Education teachers in four "transition classes" in grades 4-7. The transition class is a cross-categorical grouping of students who are identified as handicapped according to North Carolina criteria and who demonstrate behaviors that seriously interfere with learning. If an activity passed this test, teachers believed the activity would succeed in any other classroom situation! Generally, as a result of this piloting activities were rewritten at least once and often more than twice. One entire module was scrapped after piloting.

Throughout the three years of piloting the curriculum materials, the Project Director observed, and sometimes assisted, in the transition classes. Video taping enabled the staff and teachers to review, critique and collect demonstration lessons and episodes depicting instructional and management strategies.

Actual fieldtesting of the revised curriculum materials in the regular classes was not initiated until the last year of project funding. Prior to fieldtesting, lead teachers were selected by the principals at each grade level in each of the two Greenville City Schools. Test sites were also identified in two other school systems. In the Pitt County School System, two fifth grade teachers were chosen, each of whome taught low-functioning students in homogeneously grouped classes. A Greene County teacher of eight grade Educable Mentally Handicapped students also volunteered to test the materials.

In order to assure instructional consistency for evaluation purposes, the nine teachers participated in a three day inservice workshhop held in August, 1981. The teachers then used the appropriate SAK's throughout the 1981-82 school year, providing informal feedback as well as formal evaluation data.

EVALUATION

Evaluation data was collected for two years on educable mentally handicapped, learning disabled, and emotionally handicapped children as well as low functioning, non-handicapped children. Dr. Charles Coble, currently Acting Dean of the East Carolina University School of Education, served as evaluator for the project. Achievement data were collected in the "study group" of students using the performance objectives and pre/post tests for each SAK. Changes in coping behavior and development of cognitive skills were assessed using the Devereux Elementary School Behavior Rating Scale, the Nowicki-Strickland Locus of Control Scale, and a locally developed Cognitive and Coping Skills Rating Form. Attitude toward science was determined using a locally developed Science Attitude Inventory.

The evluation data are still undergoing analysis; however, general trends have been identified. With regard to achievement in science, the average mastery for all classes was 92 percent for the eight SAK's fieldtested. Anecdotal records from the teachers indicated that report card grades given to students increased when the SAK's were used.

Changes in adaptive behavior and attitude toward science were measured for both the study group and a comparison group of students. The study group surpassed the comparison group in gains on the Locus of Control, the Cognitive and Coping Skills Rating Form, and the Science Attitude Inventory. Specific results of this evaluation are available. Teachers also reported that socialization skills improved very quickly when the SAK activities were used. Students readily learned to work cooperatively with a partner. Additionally, students who normally did not volunteer responses soon entered willingly into the coping discussions.

Despite the yards and yards of computer printouts that have been generated, there probably is no adequate method for accurately assessing either cognitive growth or improvement in adaptive behavior in the handicapped population studied. Pencil and paper tests cannot be used, many skills are not directly measurable, and change is highly variable in this population. Change is as much a function of the individual student's deficiencies as of the specific skills being measured.

However difficult objective data are to collect, analyze, and interpret on these students, subjective data are readily available. The excitement generated in the science classes is obvious to any observer. One emotionally handicapped child was heard to say quietly to himself when he was able to light his bulb in an activity on electricity, "I am a success, I am a success." An Educable Mentally Handicapped child, when asked what made this program different from his other science class responded, "Last year my teacher told us that machines make work easier. This year Mrs. Taylor let us find out for ourselves that machines make work easier."

One of the most rewarding outcomes has been the teachers' attitude toward teaching science. Carol Gardner, a fourth grade teacher, reflected the attitude of all the fieldtest teachers;

> The Title IV-C Science Project is fantastic! I am enthusiastic about the project for many reasons. The children have found this program both fun and interesting. All of the activities are "Hands-on" - thus creating much excitement, enthusiasm and motivation. There is real learning going on by each child from the learning disabled to the academically gifted. This is the first program I have ever taught that I felt reached each child. The program is so well organized and packaged that a minimum of teacher preparation is required. For the first time I have been able to teach excellent science lessons without having to spend several hours planning and gathering enough materials for 32 children to all be invovled. Again, I feel that the program is excellent.

Project participants needed no crystal ball to predict acceptance of the curriculum materials by the rest of the faculty. Unknown to the project staff until the end of the fieldtest year, other teachers were already sharing the SAK's with the fieldtest teachers!

An unanticipated positive outcome of our project has been enhanced communication between regular and special educators. The development and fieldtesting required communication between special and regular education teachers. Ideas and skills have been shared and greater appreciation for an understanding of the role of each kind of teacher has evolved.

The program was opened to all faculty at Wahl-Coates and South Greenville Schools in 1982. At the start of the 1982-83 school year, all teachers in the Greenville City Schools in grades 4-6 received two hours of inservice. Although use of the SAK's has been optional, most teachers at Wahl-Coates and South Greenville are now using the program. Project CARE students are also still using the SAK's. (After the fieldtesting, the two teachers in the Pitt County Schools, determined to have their own Kits, convinced the PTA at their school to provide the necessary funds for purchase of the equipment and supplies!) Since there is no science supervisor or coordinator in this school system, promotion of the SAK's has depended upon the leadership of the fieldtest teachers and the successes of teachers who use the SAK's. Both methods have proven adequate.

There are currently sufficient curriculum materials for approximately one-half of the science program in grades 4-6. There are four modules in use in grade 4, three in grade 5, and three in grade 6 and teachers have expressed interest in developing additional SAK's. However, to date, other projects have held priority. Although no new modules are underway, the ten original units have already been refined by teachers as they use the materials. Additional learning aides are being accumulated and stored in the Kits.

Our greatest concern has been maintaining the equipment and supplies. The PTA's at both schools have constructed permanent wooden boxes to replace the original cardboard boxes. The Kits have been so well cared for throughout the past three years that no replacements of anything but consumables has been necessary! Inventory lists are kept in each Kit and teachers have agreed to a system for reordering that places the responsibility on the last teacher who has used a Kit to replace equipment and supplies immediately. The total cost of all the Kits for two schools was estimated at $3350. Replacement costs for consumables is approximately $35 per school, per year for grades 5 and 6, and $75 - $150 per year for grade 4. The most expensive replacement cost for the fourth grade is for crayfish.

OUR FUTURE

We have three concerns related to the future of this program. One concern is the continued use of the already developed materials. The enthusiasm of the teachers and the students has not waned over the past four years, and there is no reason to expect that the use of the program will decline. The second concern is the impact of the program on the learner. Data have not been collected and analyzed for any population except the handicapped. Further research will probably be dependent on involvement of East Carolina University Science Education faculty. The final concern involves further development of the program. Although no new SAK's are being created this year, Science Education faculty at ECU have applied for grant support for development of computer software to accompany the use of the SAK's with the learning disabled and mentally handicapped students. In summary, there is ample support and commitment to maintain the program, and there are options for further growth and evaluation that should be pursued.

The future of this program is secure for several reasons. Teachers who use the program like the explicit, easy-to-follow lesson plans provided in the modules and the flexibility afforded by the three ability levels. Many students who never succeeded in school are now building confidence and a positive self-image as they readily meet with success in this multi-level program. Features not unique to this program, but also appreciated, are the learning advantages of an activity-centered curriculum and the prepacked kits. Finally, the management techniques integrated with the curriculum and the structured aspect of the lessons make the hands-on experience enjoyable for the teacher and a true learning experience for the child. According to a fourth grader, Nichole,

> I think the Kit is better. If you read about it in a book, it's harder to understand. But if you have the Kit, you can work with it and do experiments. It helps you to understand - plus its fun!

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Chapter 6: System-wide Elementary Science

By

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The city of Warwick, with a population of 85,000, has 20 elementary schools, 3 Junior High Schools, and 3 Senior High Schools enrolling only 13,000 students. Our elementary student population is 6,700. The community, very middle class with both rural and urban segments, is primarily Democratic, older and, the city retains old village neighborhood rather than newer housing development identifications. We have no central downtown area. Much of our industry is based on shellfishing, electrical and jewelry manufacturing, service oriented commerce and recreational fishing and boating. Our citizens show a passionate interest in community athletics and provide a strong lobby for elderly and handicapped aid. Residents are angered by our current economic situation and cautious concerning neighborhood building and environmental changes. Our school population is projected to shrink to 10,000 by 1986.

We have laboratory rooms in each of 20 elementary schools. Our science Resource Library contains films, models, and multi-media equipment for enhancement of curriculum for the Elementary Science Faculty of our system. A full time Science Specialist is assigned to each elementary science classroom and students are assigned on a regular schedule to science classes.

Each science room has a minimum of twelve microscopes and illuminators, an academic year supply of slides and coverslips, and magnifying glasses. Most rooms have a teaching microscope and microprojector; vacuum pump; heat and water sources; safety equipment; metric and periodic charts; and class quantities of glassware, rock collections, dry cells and magnets.

The science specialists teach six to seven class periods per day. Four elementary schools have a population sufficient to require a full time science specialist while the other sixteen schools with lower student populations require a science specialist for four, three or two days per week.

Our science specialists teach in buildings with an average age of twenty years. The science specialists, averaging 12 years experience, are cooperative, innovative in use of teaching materials, and update curriculum materials annually. Most are computer literate and contribute long overtime hours and personal funds toward making the science program successful in their assigned schools. Our curriculum is teacher-designed and child-centered. Process oriented hands-on laboratory sessions meet 110 minutes a week at the intermediate level and thirty minutes a week at the primary level. We study the Marine environment as part of each grade study of local plants and small animals; Much of this in outdoor classes. We also launch rockets and have science fairs. But, Science still is not regarded as a basic academic subject in the elementary grades. It is considered in the same category as art, music and physical education. Social studies and science are often equated as peripheral to reading and mathematics.

While our former program was hands-on and designed by teachers, each elementary school had its own program based on multiple texts. Only the intermediate grades were taught by science specialists and the science supervisor was responsible for K-12 science and had too many duties. The duties of the supervisor were such that the science specialists were left largely on their own to implement the program. Ideas were not exchanged and evaluated within the group on a regular basis. Some teachers relied heavily on text oriented lessons, some the project approach, some used the lecture-audio-visual technique, and some developed process oriented laboratory lessons. Some science teachers taught biology or earth science or physical science for more than one quarter according to their own interests. Intermediate students were taught in the science laboratory rooms in each school while primary students were taught by classroom teachers in the classroom on a non-regular basis.

The science teacher and the classroom teacher usually followed a curriculum guide but with their own individual teaching technique. The intermediate grades were scheduled for 95 minutes each week; usually in two sessions and the primary grades were allotted 30 minutes of classroom time each week. This classroom time was not a generally followed schedule since most classroom teachers did not feel comfortable teaching science. And, each science specialist before 1976 ran a separate version of the curriculum. But, the science specialists, with few exceptions, used the hands-on approach for the intermediate grades. The idea was effective no matter which content area was used. The change over to a departmentalized organization in 1976 brought about some trauma as well as educational improvement.

OUR BEGINNING

By 1976 a revision of the 1963 science curriculum was mandated along with all other curicula in the Warwick Public Schools. The need for revision in the elementary science curriculum and program was most apparent in the need for students to:

1. leave grade six with a common academic experience
2. use critical thinking skills in the solution of related science problems.
3. have less repetition in the junior high school of subject matter already emphasized and covered in the elementary program.
4. easily transfer from school to school within the system.
5. be evaluated with Criterion referenced testing.

The sequence of changes made in the curriculum over the period from 1963-1983 reflect a committment to progress. The physical environments of laboratory classes progressed from grades four, five, and six to grade three and then to grades two and one. Texts changed from multiple to one reference basal text, equipment has expanded, hazardous chemicals were eliminated, discrete teaching units spiraled through grades 1-6 on a quarterly basis. The curriculum became process and skill oriented for transmission of learning to other disciplines. Enrichment activities were designed for the gifted and handicapped.

The change was gradual from 1976-78 as teachers, principals and the department head met monthly to discuss, develop, write, and rewrite a new curriculum program for grades 4-6. And, the adjustment to a science specialist-taught curriculum at every grade level had to be negotiated through four years of union contracts. (1978-82).

Inspiration for our program had no one source. Throughout a career in science research and teaching, my own teachers, associates, and students have believed in my ability to find a way to communicate science knowledge to those who need to know. I have a deep sense of responsible obligation to do more than think about good evidence and the solution to problems that are within my ability to act upon in some positive way. We depended on dialogue and communication within the elementary science department to bring about a unification of purpose and objectives. In the process, we identified 14 processes and 51 basic skills to serve as basic science education requisites in the program. Much of this was facilitated by System wide National Aeronautics and Space Administration Workshops and programs.

THE NEW PROGRAM

The Warwick Elementary Science Department now operates a basic science curriculum stimulating students to coordinate effort for teamwork. Detecting and correcting the knowledge gained through the program of "hands-on" science learning activities, basic content and emphasizing the individual's responsibility and accountability for personal efforts form the curriculum.

This teacher-designed program, taught at every grade level in laboratory settings by science specialists emphasizes direct experience and the process of science. Computers are an integral part of the curriculum as are discrete lab skills which are useful to students as they learn and use science. And, our former science supervisors position was redefined as "Elementary Science Department Head" making elementary science a unified department.

Now, we teach spiraled, quarterly units sequenced to be coordinated with language arts, math, and social studies. We use a single text but as a reference rather than a core or base. At the heart of our program is the Science Resource Library. The cultural values and behavioral activities of world society rest with increasing weight on creative science and applied technology in the twentieth century. The knowledge vital to the survival of human beings on earth requires adaptability in the teaching-learning environments.

The Warwick Public Schools established and designed a flexible coordinated program of science study in the elementary grades in order to facilitate and strengthen connections between the perceptual and imaginative understanding of the environment. The elementary science department in Warwick has existed since 1963 to provide a basic source of education by which each individual student may quantify and qualify the environment according to his/her own patterns of learning.

OUR GOALS

Children need a science program taught in the affective domain so that the intellectual processes taught through science studies may transfer and reinforce these same processes needed in literal studies. Hands-on science serves to bring them to a proficient stage of abstract reasoning when they meet cognitive subject matter concentration at the secondary level of concentration. The training, through concrete operational science activities, gives the students needed practice in counting, measuring, classifying, observing, data gathering, data processing, inferring, and predicting.

Children need a science program which closes gaps in the perceptual learning process before they apply misperceptions to cognitive subject matter taught at the secondary level. And, they need a science program that facilitates model activities designed to direct and guide their awareness of benefits and problems brought about by rapid technological changes in human living conditions.

Children need a program of science which serves their future decision-making choices in career preparation by giving them visual and activity experience with current research and technological tools such as rocketry, microscopy, rapid data communication in meterology and health diagnostics, population growth, bridge and road design, aircraft control and design, ecological models, solar energy, fundamental design and use of microcomputers, agriculture, and marine and space life systems. We want elementary school children in the Warwick Public Schools to have a systematic science program so they may transfer between schools without having to relearn concepts and processes according to different teaching styles.

The philosophy guiding the day-by-day teaching of elementary children in our system has been developed over a period of eighteen years. It represents the personal experiences of the science specialists who have been observers of the educational interface between a curriculum of learning science by "doing" and the student. It also represents the observations of the supervisors and administrators who have studied the interaction between the elementary science specialists and their classes and the interaction of ordinary classroom teachers teaching science and their classes. These observations have incorporated research on cognitive structure and processes relative to the content of science, the teacher and the learner. As a result, we feel an elementary science program should:

* Allow children to develop individual learning patterns.

* Teach the child to use the processes of learning as well as content.

* Provide a simultaneous teaching-learning experience.

* Be taught by a teacher with proficient knowledge in the content of science, the stages of cognitive behavior of the learner, and an awareness of self as a visualizer of analyser when teaching and reacting to students.

* Be structured so that individual learning patterns are positively reinforced by learner's acceptance of personal responsibility or locus of control.

* Be interdisciplinary in nature; influencing the cognitive assimilation of concepts experienced by the student in other learning environments.

These philosophical perspectives are listed with the knowledge that the ongoing procedure of continuous curriculum appraisal and publication of newer cognitive research will inevitably cause gradual transformations of our ideas. It is also understood that the elementary study of science must fulfill a useful role for the student in later stages at the secondary level. The social influence of the elementary science curriculum has received considerable study in this current revision. There are recommended teaching procedures and classroom activities which correlate the processes of cognitive learning and science content to life roles that the student will find valuable in data gathering. These curriculum activities are vital in the affective placement of concepts about self and the environment during the elementary years of human education. The National Aeronautics and Space Administration's Auditorium programs, Mobile School Visits and Teacher Aeronautics and Physics Space Workshops for teachers have been a yearly part of the program since 1975. The students build and launch their own rockets, take part in simulated flights after working daily for units studying the effects of space on man and learning how to run calculations for life support and navigation in space. Students have units building small mechanical digital computer encoders, memory drums and decoders. The students have active practice in studying the balance of man and the environment through field ecology, bird watches and marine activities.

For a basic text we use Addison - Wesley's **STEM** program. We also have National Geographic Learning Shelf Kits, National Museum of Space Science Materials, NASA Elementary Science Materials, R.I. Coastal Awareness Materials, and URI Energy Curriculum Materials. All of these are used to complement instruction for the Curriculum Guide. We spend $2.53 per child each year on books, periodicals, and science supplies.

The Curriculum is one written by science teachers, administrators, and parent consultants for the students of Warwick. It is a teacher-directed curriculum based on the process approach to learning. Interdisciplinary in application, it is updated twice each year and uses a basal published text for reference and homework assignment in addition to teacher prepared activity sheets. Students are evaluated according to activity participation and concept formation.

Broad content areas are emphasized in a six grade spiral. Energy, matter, heat, light, electromagnetism, sound, chemistry, and interrelationships between force, work, momentum, and power as well as tansformation of energy types and measurement units are rooted in this study. Study of simple machines and balancing lays the foundations for understanding balancing in equations. We also study properties of color, shape, texture, size and physical states such as solids, liquids, gases, plasmas. Studies of energy, matter, earth science, space science and life forms lead to classification, biome studies, biochemistry of life forms, habitats and crowding, communication and behavior of life forms, living cycles, and reproduction.

Broad content areas are as applicable in a kindergarten class as they are in a high school science class. The content area of energy knows no barriers--it is persistent in form throughout the universe. The broad areas of content are universal and descriptive. Students learn environmental science concepts under four major content areas:

Matter and energy
Earth science
Space science
Living environment

Students become intellectually cognitive of this knowledge through "hands-on" activities involving eight basic science interpretive processes. The dynamics modifying each universal or broad content area are:

a. Space-time relativity (spatio-temporal measures)
b. Pattern Groupings (Classification)
c. Cyclic Succession (Sequencing, Periodicy)
d. Integrated Systemics (behaviors of association, identifies, correlations, aversions, reciprocity, symmetries, assymetries)
e. Communication (Quantification of transmission clues for intelligent perception, quanta threshold values for human perception, concrete and illusory perception qualities)
f. Interdependent Webs.

Students also are given the opportunity to work in project groups and develop an awareness of self as a contributor to the group's success. Students develop resonsibility for self-paced learning by completing study tasks in science. They study energy problems as applied to energy conservation in the home and community. Decision making expands from project work to existing societal issues of genetic engineering, chemical and nuclear pollution, balancing the natural environment, conservation of animal and plant life and natural resources.

OUR PROGRAM

Each module of the curriculum guide is adjusted to the span of average children's intellectual development within each grade level. The Broad Content Area, Common Dynamics, Learning Objectives, Science Skills, and appropriate References are correlated in the Scope and Sequence Chart for each grade level. The modules may be selected in any order within each grade level, but each module should be taught during the school year.

The curriculum modules have been set up for each grade level and with a wide choice of reference lessons from newly published, philosphically compatible programs so that children may be introduced to activities correlated with their intellectual state of development. By providing a variety of references, this curriculum guide seeks to avoid the incidence of children marking time on material that is below their stage of reasoning. The guide should be a handy reference in selecting materials to reinforce learning objectives. The teacher should select the behavioral objectives and science skills, for either introductory exercise or reinforcement. Once the module is started, it should be completed.

It is hoped that the listing of specific objectives for each module will provide a basis of learning experience from grade level to grade level so that the cummulative effect will be a readiness for the formal intellectural operations required by the subject matter content at the secondary levels.

An inquiry process approach laboratory written around a sequential repetition of process and operational skills is the core of the program. These develop the affective and cognitive areas of the student with the four broad concept areas repeated in a six year spiral. Each year's advance in the spiral requires a base of the previous year's process experience in the content area. The program stresses the interdisciplinary use of process learning in the science, social and literal areas of the elementay student's studies. For example, in ecology, we study tide pools, beaches, and woodlands. This involves constant decision making and the gathering of data to make decisions. Rock and soil studies involve collection of data and the growth of the student in science knowledge for identification purposes. Weather Stations use instruments for prediction. Astronomical Studies of star groups, planets and moon and sun cycles allow prediction of future motion and earth effects. Computer simulations of actual events require application of science knowledge and decision making.

The process hands-on curriculum demands students be actively engaged in data gathering. The core curriculum lessons usually produce student project spin offs; work carried over to the homeroom class and home of the child. Students evaluate these projects and reports when presented by other students in class. Clean-up and material distribution is a student assisted activity. Students are permitted to work in compatible self chosen groups for many of the labs but rotation of partners is also the rule. Evaluation of student data is based on evidence; a routine activity in the daily teaching of science.

Each year, for both primary and intermediate levels, speakers and programs from NASA, Marine Awareness Groups, Audubon Society, and local TV Meterologists come into the science classes. The classes in turn visit the university observatory the local Airport, Boston Museum of Science, Mystic Acquarium, and the Boston Hayden Planetarium as well as local farms and zoo.

Films and filmstrips are presented ("Search for Solutions", "Life of Thomas Edison" "Madame Curie", history of the US Space program "Debrief Apollo 8", "Spider and Gumdrop", "Apollo 11", National Geographic films on "Our Universe", "Our Dynamic Earth"). Problems in the conservation of the earth's unique resources and life are discussed, researched, and developed into projects for science fairs and school displays. Emphasis is placed on the value of human life and creativity and discovery by humans of the fundamental arrangements of energy and matter existing in the universe. The possibilities of future expansion of life onto space stations and careers developing from electronic processing of information form valuable student projects.

The process laboratories of the program are interdisciplinary in nature and vocabulary lists are part of the curriculum for each grade level in each content area. Current knowledge as well as traditional and historical content are part of the lab lessons. The curriculum identifies flexible use of content materials for teacher and students so that practical application of processes of learning, skills and subject content can be made across a broad scope of daily life activities. Mathematical problems in measurement of length, time and mass form a part of the curriculum spiral from grades 1-6. Special emphasis is given to understanding vector analysis and mathematical balancing of forces.

Students are used to handling data charts and graphs. They assimilate the logistics of predicting from graphical data with ease and make the transition to computer programming from data gathering quickly. Students are literate and deeply interested in space and astronomy. Students use the mechanics of algebra by the end of the sixth grade for solving force and work problems. Students have a good knowledge of animal and plant classification, nutrition and the structural system of living things, aircraft and rockets. The basic electricity and magnetism relationships and in chemistry atomic structure and acid and base relationships are known.

Students take part in an overnight ecological study camp and an annual Rocket Launch and model aircraft "flyoff" days are notable events for community observance. Parents become involved in helping to organize these events. Science Fairs and displays also involve community volunteers. Students take part in community litter clean up campaigns and archeological digs. Each activity grows out of correlated laboratory lessons in each content area of the curriculum spiral. Students build projects for community competitions sponsored for the elementary students in energy conservation, environment cleanliness, human health, disease prevention, and for Warwick Museum displays.

Warwick affords students the opportunity to build bird blinds for bird watches while easy trips to estuaries and beaches for marine studies and fresh water ponds are within reach of each school. These resources are used frequently for lab study sessions in grades 1-6.

Data gathering for push/pull work measurements, weather stations, aquarium and terrarium projects, rock and mineral collections, incubation of ducks, biome traverses, space flight simulations, seasonal astronomical sky pictures, botanical collections, gardening and bird watches stress trial and error importance and the development of purpose-directed play. The child is doing and understanding the environment from the point of human perception. At the same time the child knows the feeling of a positive role socially by learning to appreciate and care for the environment.

Student criterion exams given system wide at designated grade invervals and times of the year give a better picture of student capabilities to achieve and curriculum effectiveness. Students leaving the 6th grade and entering private schools receive scholarship awards based heavily on their science achievement scores. Warwick students have a good representation in local institutions of higher learning in the sciences and engineering degree courses.

But, a valid testing program for students who are receiving process oriented instruction at the elementary level needs to be expanded and developed from this program. The department is in the process of completing pilot testing of teacher developed criterion tests. Individual teacher made tests always contain evaluation questions allowing the students to apply science knowledge to possible solutions of personal, social and futuristic problems of living. Competitive Science Fair Projects are evaluated for growth in student knowledge, workmanship and oral presentation.

Our evaluation must be expanded to include criterion testing and questions more specific to the process orientation of the program. I would like a sixth level final exam system-wide after the criterion testing is established. We could have a system-wide sensory perception evaluation for kindergarten students as a prerequisite for entering the first grade science laboratory course. If we were to correlate the mathematics curriculum to specific curriculum requirements of the science curriculum, students might avoid math inequalities in the 5th and 6th grade science activities.

For the science specialist teaching the elementary students in Warwick the goals of teaching an interdisciplinary process oriented program using science as the vehicle of instruction have become deeper and stronger. **NSTA** and national recognition has brought growing strength and realization that the department has fulfilled a very important academic role in the development of Warwick's students' intellectual state. Dialogue between the faculty is developing well for implementation of the curriculum at a higher level pedogogical structure.

The teaching styles of science teachers and the learning styles of students are recognized in the program organization and the curriculum has been written so that it is flexible. Individualization of projects and home assignments maximizes the potential development of students because they are working and learning at their own pace with an acknowledgement of self-responsibility for what is learned. Group project work stresses respect for the role and ideas of others and respecting the rights of self.

Each Elementary Science Specialist;

* **Plans** each lesson for the scheduled classes and keeps a lesson plan book for administrative inspection

* **Prepares** activity sheets for the lessons

* **Keeps** an inventory list of all texts, supplies and equipment in assigned schools

* **Coordinates** science activities with other subjects

* **Participates** in IEP planning and evaluations

* **Tests and evaluates students and records report card** grades 4 times a year for each student

* **Conducts** and organizes school science fairs, displays, and field trips

* **Distributes** and cleans-up all materials used in science

* **Prepares** a need list for department budget planning

* **Organizes** auditorium and speaker programs for individual schools

* **Teaches** computer awareness sessions for science students

* **Serves** on curriculum committees

We would like Science Teachers to have a good understanding of current knowledge about learning and brain physiology. A thorough knowledge of applied learning psychology including child psychology, psychology of personality, and cognitive psychology would allow teachers to understand psychological needs of students. Some apprenticeship training in the application of learning psychology in the elementary classroom would be great. An effective science teacher needs at least thirty semester hours of science content courses if they are to be able to design good activities. And, proficiency in at least two simple microcomputer languages are skills I'm looking for now as well. Most importantly, teachers need a willingness to teach science using the holistic-process-oriented approach.

These teachers teach a "hands on" lab according to a science teaching schedule for grades 1-6. If you visited, each teacher would be seen setting up materials for distribution and probably spending a portion of their lunch or preparation time with some student or students requiring special conferences on projects. During preparation time they repair equipment or prepare materials for future labs. Teachers might be seen arranging displays which correlate with subject matter being investigated or meeting with other teachers in the building about the progress of students or correlation of subject matter areas.

Teachers avoid using lecture, demonstration or reading - question answering in instruction. They rarely use commercially prepared visual aids and never run a laboratory session without pre-teacher trial. Teachers avoid cutting off student questions or responses and work hard at seeking multiple answers to questions. As a program we try to eliminate repetition of lessons for students in split grades. We never cut class time to less than 55 minutes per class period or leave out individualization of student learning. We do prepare well in advance and give homework in the form of projects and research reports. We do not keep students tied to a grade level of learning.

Now that our program is well-developed and operational, science teachers have become members of an integrated department capable of acting as a group for the good of the curriculum and the students they serve. Elementary science teachers now have attained some academic recognition by science teachers in the junior and senior high schools. Also, science teachers communicate with each other more frequently about curriculum innovations and share more teaching ideas. Science teachers are less worried about initiating departmental criterion testing and departmental tests and competition among the science teachers for administrative and public approval is greatly diminished and for the most part no longer exists. The Elementary Science Program is regarded as an integrated, strong entity although it still has a long way to go to reach full regard as basic subject in the minds of the public, aministration and other teachers. But, science teachers have become a determined group seeking to establish science as an academic discipline rather than a mere itinerent subject.

The program maintains Institutional subscriptions to **Science and Children** and **Scientific American** and the Resource Library Center has a collection of relevant methodology texts. Professional conferences on content areas are attended by faculty while inservice workshops are held by the system. Interdisciplinary seminar-conferences are held with the Superintendent. State conferences on education and educational methodologies for the gifted and handicapped are attended at the local Universities. Warwick elementary science specialists have an institutional membership in **NSTA**. They make monthly use of the star charts and posters and attend the regional and national meetings. The trends for elementary science education in the magazine enable them to keep up with current ideas.

Mechanisms built into the program are a review of curriculum twice per year and resultant ordering of materials and equipment for a better quality of coverage given to traditional and currently needed subject matter. Inservice courses conducted by NASA, the Energy Council, and Micocomputer companies under the direction of the Department Head serve as update subject matter for science teachers. Field trips to Science Museums, aquariums, and environmental camps are regularly scheduled as part of the curriculum. The science resource center allows multi-media materials to be borrowed throughout the system by both science and classroom teachers. Visiting special programs for marine and energy awareness as well as subject matter special speaker programs are all scheduled throughout the system on a fairly regular basis through the elementary science office.

Each science specialist holds a school science fair each year and individual science specialists bring their students to energy, nutrition, dental, medical, space, environmental competitions sponsored by professional societies engaged in these science related occupations. The students are gradually working into computer building (digital 4 K mechanical models) so that they understand basic programming from the binary bit integration circuits.

Other support mechanisms include community PTO-PTA fund raising for equipment and field trips and a local paper, **The Warwick Beacon**, and parents who fought to keep the program from being cut during 1979-80. Our administration, the Superintendent, School Committee and Assistant Director of Elementary Education were supportive. Classroom teacher support and cooperation has been strong and vital.

SOME NEEDS AND CONCERNS

The community changes slowly. However, during the last eight years there have been three major changes: a drop in student enrollment; tightening of city and school budget, and mandated federal and state laws for education of learning disabled and gifted students.

The equipment budget was dropped for four years so that fourteen year old texts could be replaced with process oriented books. Expensive materials were replaced by generic supermarket products and homefound contributions and PTA and PTO aid were solicited through science fairs and parent dialogue.

The vintage 30's, 40's and 50's schools should be replaced by schools of current architecture which could consolidate more students in one school. Science rooms could be constructed which would facilitate the teaching of biological, physical, chemical and primary oriented science content. This would reduce lost instruction time in teacher travel, travel per diem, organize equipment and material and provide security for expensive equipment.

We would like to schedule a rotating teacher team using the talents of those teachers who have exceptional expertise in teaching primary students and the learning disabled. Some science specialists use the process-oriented labs much more effectively in the biological, astro-physical, mechanical, electrical, geological or oceanographic areas of study than others and tend to devote more time in class to these students in class. A rotating schedule of subject area experts from school to school would also be a more effective way of upgrading student interest and perhaps achievement.

Networked microcomputers programmed with curriculum activities and correlated with a student lab station equipped with materials could enhance the holistic elements of the program and reduce problems with split-grade instruction. This might provide specialized material for the instruction of the learning disabled and gifted mainstreamed into an average class and give science instruction time to correct individual student misperceptions and misconceptions as they relate to science and learning. Tests could then be used more effectively with rapid feedback results to the student and parents.

Science should become a basic academic subject at the elementary level along with reading, mathematics, and social studies. Science should be taught in at least two thirty minute periods per week at the primary grade level, and three 50-55 minute periods per week at the intermediate level. Certification should require three successful years of elementary classroom teaching and a minimum of thirty semester hours of higher education courses in the content and methodology areas of science education.

The administration above the level of the supervising department head needs to recognize science as a basic elementary subject and set up certification requirements for elementary science teaching similar to certifications already existing for elementary physical education, art and music. Our morale would increase if we could erase the word "itinerant" as a preface to "elementary science teacher". Intellectual concensus says this means someone lower than the traditional teacher.

In-service programs explaining the interdisciplinary nature of process learning and holistic education should be set up within and outside the system. Explanatory booklets and illustrative sample lessons also need to be printed and distributed. We should set up a dialogue with local colleges and universities so that consultants, teacher training programs and courses may be set up with corresponding graduate and undergraduate credit. We could set up talks with state certification officials so that such a program will lead to the certification of elementary science teachers. We will continue to use the services of NASA and the Space Museum for the graduate credit program that I have directed since 1975.

If we obtain elementary science teacher certification and provide in-service courses on the methodology of process-oriented elementary science instruction, I feel teachers will put a great deal more time and energy into lesson preparation and the teaching role than ordinarily required by elementary classroom teaching. This will lead to more positive dialogue with peer teachers and administration and establish good communication with the parents of elementary students and the local media.

If higher education communities act with strength and concentrated effort to educate administrators and teachers in the holistic way human beings learn with science as a vehicle of process oriented learning, then up-grading the science-technology mathematics knowledge of the United States student will proceed as envisioned. The cooperation of the software industry for launching disk and cassette programs in the human process learning mode is essential. Otherwise, the path of least effort and cost effectiveness will be taken by the largest majority of school systems in the United States and the renewed effort to upgrade mathematics, science, and technology will only deepen the huge gap that now exists between those who know and the science illiterate. Misperceptions and misconceptions will grow exponentially and the task of re-education and re-training will become impossible.

Inservice teacher education workshops have played a key role in educating the teachers in current content material and expanding the curriculum coverage. Teachers now adapt knowledgeably to the psychology of the process oriented curriculum, producing science teacher dialogue, and preparing them for the introduction of microcomputers in the classroom. The role of workshops is bearing fruit as the teachers become more critical of what is written and express concern over the need to share materials and procedures for teaching science. It is hoped that such workshops and inservice courses will continue to serve the needs of these teachers and their students in the future.

Student enthusiasm and interest for science are great rewards. Parent approval and cooperation in maintaining the science program is rewarding also. We are motivated to keep learning how to adapt science as a learning vehicle for the many individual styles of learning expressed by student in grades K-6.

Individual contributors to our science program include:

Dr. Clyde D. Bennett: Superintendent	Authorized curriculum revision and participated in solution of problems.
Mr. Amedeo Merolla: (retired, 1983)	Chairman School Committee, kept budget of department and elementary science department from being cut from system in economic crisis times.
Dr. Nora Walker: Assistant Director, Elementary Education	Final writing of 1978 and 1980 curriculum Elementary Subject matter coordination. Writing of final draft of Criterion Test
Elementary Science Specialists:	Sixteen teacher members of the Elementary Science Department who wrote the curriculum draft (1980 and contributed heavily in the 1978 outline of the program and who make the program work.
NASA Educational Program Personnel:	Making present technology understandable and real for teachers, administrators and students.

Chapter 7: Elementary Science Program

By

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Mesa Public Schools, with 41,000 K-12 students, represents a highly diverse population with many ethenic groups and two Indian reservations. Over 20 languages are spoken as the primary home language. Approximately 17 miles from Phoenix, the community is a mixture of agriculture services, business, and industry. With over 29,000 elementary students, every type of ability level, handicap problem, socio-economic status and attitude are included. Household income averages about $22,000 and our average age is 34. Only 8% of our students do not graduate from high school and 13% of our community are college graduates.

Under our "old" program, each school in the district developed its own program for science. Most used the book **Concepts in Science** while several schools used the **SCIS** program and two schools had **ESS** materials. One school had two special teachers for intermediate science. While schools had books, materials, and science requirements, there was no assurance that science was taught. Teachers had to gather all of their own materials or skip the hands-on experiences. And, with no system-wide curriculum, costs for science ranged dramatically from school to school. Little or no teacher training was provided in the district and it showed.

Most teachers had almost complete freedom of what and how to teach. Some principals were more involved in monitoring than others so, even in schools using **SCIS** or **ESS**, there was a wide range of implementation from teacher to teacher. Some teachers were models of inquiry teaching, some presented information, others taught science reluctantly, and a few taught no science at all. Even when science was being taught, it may have been taught poorly or in ways which were not compatible with how children learn or the nature of science.

As a result, student test scores for the sciences were low. Junior High science teachers complained that students were coming to them with poor science backgrounds and a dislike for science. Our teachers felt that they were not doing a good job in teaching science. We could see that our lack of uniformity was leading to science learning of questionable value. Students were leaving with the wrong attitudes, too little knowledge, and no desire to continue in science. We needed a change of curriculum as well as a change in our instructional strategies.

THE BEGINNING

In one sense the change to the new program was sudden. One of the math resource teachers in the district requested that his supervisor, Dr. Gerald (Mike) Mikesell, Director for Math & Science, grant him a half-time position for the following year. At the same time, Dr. Mikesell learned that Susan Sprague, an intermediate science teacher at one of the district schools, was resigning in order to pursue her doctorate in science education. The other half of the original position was then offered to Susan with no specific job description other than, "Our elementary science program needs help." During that spring and the following summer, Mike and Susan outlined their plans and hopes for a science resource center.

Without a commitment to the program by Mike and Susan and the acceptance of the program by the superintendency, we could not have succeeded. Dr. George Smith, Superintendent of Mesa Public Schools, frequently jokes that his aim is to hire the best person for the job and then get out of the way. He did just that and the freedom that we had to develop our program was essential to its success.

From the teacher's point of view, though, the program started very slowly. During the first year, teachers were told "Just keep on doing whatever you did last year and we'll get back to you when we get something ready." Teachers who were interested in increasing the manipulative materials for their program contacted the resource center and were given materials as soon as they were available. These teachers were trained in how to use materials as well. For the most part, though, these were teachers who already had a personal committment to an activity-based science program. As a result, the experiences they had with the materials were highly successful. Their success was observed by their fellow teachers who then had a greater tendency to request materials for their own use. It was not hard to figure out. Our children liked their active involvement with the SCIS materials as well as their opportunities to do science and make decisions.

An accident helped make a strong point and speed us along. Although 7th grade science is a required subject, in the spring as we were planning our program, one of the junior highs inadvertantly listed science as an optional rather than a required class. Two of the feeder schools for this junior high are frequently used as matched schools for research purposes because of the similarity of their student populations. One school used a traditional textbook approach while the other used the SCIS program. An unplanned but highly significant research study emmerged. From the elementary school offering the SCIS program, 96% of the students chose to take the "optional" science course. Of the students at the school with the traditional science textbook, only 4% selected science. This lucky scheduling accident was an important factor for emphasizing both our problem and one part of a solution. It was apparent that if liking science was one of our goals then SCIS was doing something that the more traditional program was not. So, we knew our hands-on kits would work; all we had to do was put them in the right places. So, we began designing a way to see that all 29,000 of our students had hands-on science. Since lack of materials is a frequent excuse for not teaching science, we decided to develop or purchase science kits which would have all materials needed. These kits would circulate from a central district office to each school. Lack of materials would no longer be an alibi. Going slowly had its benefits and one of the reasons for the program's success is probably directly related to our use of a gradual non-threatening implementation process. By the third year, when use of specially designed program kits was mandated, over 90% of the teachers were already using more kits than required.

During the first year, a series of workshops by grade level were held. These were probably necessary but were not as effective as the individual or team training sessions which followed in later years. We have found that in a one-on-one training situation, usually in the teacher's own room with the kit materials the teacher will begin using, a 20 to 30 minute training session is adequate. For longer units, a second training session may be held later in the year. These training sessions normally occur during the classroom day while students are at the media center, music, or P.E.

All state adopted text books in elementary science were compared for content by grade level. Content kits were then assigned to a grade level by selecting the most common grade level for that topic. When two adjacent grade levels covered a content topic with equal frequency, the topic was almost always assigned to the higher grade level so that supplementary reading materials from any textbook series could easily be read by their students. In addition to the content kits, kits related to the processes of science were assigned by grade level as in the **SCIS** science program.

Once the grade level listing of content and process kits to be developed was agreed upon, additional **ESS** kits were added to grade levels with a small number of kit topics. Wherever possible, commercial kits such as **SCIS, Silver Burdett,** or **ESS** were used directly or adapted. When no commercial materials were available for a topic on our list, a Mesa kit was developed. This was done with our resource staff providing the original rough draft which was then field tested by classroom teachers. A second revision was completed by the resource staff and a second field test series was then run. In most cases, the final kit was developed following the second series of field tests by teachers.

After the kits were purchased or developed, teacher training, usually at the teacher's own school, was available before the kit was used. Even now, after each use, the classroom teacher is asked to evaluate and make recommendations for the unit's revision. These recommendations lead to the next revision of the unit. Completed units are revised or supplemented regularly even now.

Our superintendent has been universally supportive and appreciative of the job done. Although state budgetary laws in Arizona seriously restrict the amount of money available for education, our administration has been allowing whatever the budget could bear. Moreover, they have allowed us a great deal of freedom and creativity in how to spend the money available. Principals at our elementary schools have been supportive also. Most of them wanted a stronger science program and were glad to support a district program providing the materials, incentive, and instruction the teachers needed. While administrators and teachers were critical in establishing the program, community support has been important in the continuation and expansion of the program as well.

OUR PROGRAM

Each teacher, grades K-6, is required to teach at least four kits per year including at least one each in life science, physical science, and earth science areas. No formal studies have been done, but through the

Elementary School Review Process and through the comments on the teacher evaluation sheets for the kits, it is apparent that the teachers are much happier with the new science program. Another indicator is that the average Mesa teacher teaches almost twice the number of kits required by the district.

Our 34 elementary schools vary in age from 33 years to "under construction." Every type, shape, and size of classroom is available in our district. Class size at the primary level ranges from 22 to 34 with a mean near 26. Intermediate classes range from 27 to 39 with most classes having 32 students. So, we attempt to make our kits flexible enough to function well in any classroom arrangement. We have had only one negative experience related to classroom facilities. This was in a poorly constructed portable where the teacher was valiantly attempting to do the Gases and Airs unit. The shaking of the room whenever anyone walked from place to place was devasting to test results. Even in this case the teacher did a marvelous job of discussing experimental control and variables before switching to another kit.

Materials are a key factor in making this program work. Each kit is expected to contain all of the materials (except normal classroom items such as chalk, scissors, and pencils,) that the teacher needs to provide the hands-on experiences for students. Bulk purchasing of these materials saves enough money to allow for the purchase of additional specialty materials. While these specialty materials are not essential to the success of the program, they are very useful. Such materials as solar ovens, environmental energy simulators, and a portable planetarium really help enrich our curriculum. Also, the sharing of non-consumable materials such as human body models, audio visual components, and reference materials allows a smaller amount of these materials to be purchased than would be necessary if each individual school provided their own. This additional savings is used for the purchase of even more specialized items or for the teacher training component.

While each school receives kits from the district office, each school also maintains a basic science kit which is checked out through the media center. This kit contains magnifying glasses, thermometers, hot plate, balance with weights, and other materials as requested. This basic kit is for student or teacher experiments that come up on the spur of the moment when there is not time for materials or kits to be ordered from the resource center. We are also making good progress on each school having its own microprojector.

Each school has a delivery day each week when the kits or special materials requested are delivered. All animals or animal units are sent out through a special delivery system which delivers on Mondays and picks up on Fridays. Once at the school, the individual teacher is responsible for distributing materials and cleaning up and repacking the unit when finished. In many cases, part of the inservice session directly related to the kit will include tips on the most effective distribution arrangement for those materials.

OUR GOALS

Our overall goal for all students is that they develop an appreciation for science and learning and have the reasoning and evaluation skills necessary for active and effective citizenship. By grade level we want students to:

K. **Explore** the senses as a part of the general readiness program

1. **Perceive** and describe observations.

2. **Perceive** changes and continuities in the natural world.

3. **Recognize** and control variables in simple experiments.

4. **Recognize** the difference between observations and inferences in experimental settings.

5. **Set up** and understand classification systems and set up and carry out simple experiments.

6. **Recognize** and predict the consequences of man's use of his varied environment.

Our program has attempted to deal with each of these goals. Not every goal is incorporated into every kit but specific efforts at meeting these goals are frequently encountered by students at each grade level. A variety of other goals integral to our science program are incorporated in various units. Looking at a sampling of units from the sixth grade curriculum illustrates this integration. In Gears & Technology, we stress possible alternative futures and the need for adjustments on the part of society. Our Non-Urban Ecology unit deals with land use in Arizona and involves students in the multiple use problems of adjacent desert areas. Science related social issues such as these are common throughout the curriculum. The Desert/Mountain Survival unit requires students to inquire and make practical decisions based on their knowledge of the two environmental areas. Careers are discussed in many units such as the 6th grade Disease and Nutrition unit. We also consider value, ethical, and moral aspects of science-related social isues. The Non-Urban Ecology unit is centered around such issues.

Teachers have their choice of which kits they choose to use in order to meet the district goals. As issues come up, additional update sheets can be added to any kit that goes out, keeping them closely tied with community problems related to that topic. We continually focus on man's responsibilities to the environment and each other and we use the community, natural environment, and the students themselves as resources. Units such as The Desert/Mountain, Electricity, Disease & Nutrition, and Genetics specifically allow students to study community resources and to use themselves as foci of study. The student as an organism in a cultural and social environment is a concept stressed whenever possible but is probably best exemplified during the school camping experience.

Most kits offer a wide enough variety of activities so teachers can provide activities of an appropriate level for all their students. Most intermediate kits also include one or more opportunities for students to become involved in problems of their own selection.

GRADE	RECOMMENDED CORE UNITS
K	Beginning Senses Science centers.

1	Sorting Growing Seeds Introduction to Animals Animal Centers Weather
2	Changes Animal Life Cycles Energy Desert
3	Variables Earth changes Starting From Seeds Animal Adaptation
4	Machines Rocks and Charts Budding Twigs/Plant Puzzles Animal Study through Insects
5	Urban Ecology Mystery Powders Man in Space Health
6	Non-Urban Ecology Electricity Small Things Desert/Mountain Survival

All students are involved actively with the kits. Student involvement in planning lessons and classroom management varies from teacher to teacher and from kit to kit but students do make decisions and self-evaluate. Students set up and conduct experiments to explore specific questions. They discuss the possible interpretations of their experimental results and consider what experimental problems might make their results non-representative. Students do library research related to specific science topics and work independently in small or large groups. They discuss and seek solutions for local environmental problems.

The teaching strategy most appropriate for this program is an inquiry approach where students actively explore ideas. Teachers facilitate this exploration by asking probing questions; waiting for responses; and accepting, without evaluation, all responses. Teachers also spend much time merely observing students. As much as possible, teachers avoid giving out direct information or limiting a student's opportunity to define and solve his own problems. Inservice teaches strategies, content, and management technique. Through inservice, our teachers develop a rationale for teaching science. This takes time but teachers have been moving in this direction over the last several years.

We have run many teacher education workshops, often during district early release days. Others were 16 hour workshops for one hour of district inservice credit. These workshops will continue and in most cases need to be repeated many times in order to accomodate teacher requests. However, most of our training is done on a one-to-one basis in the teacher's own room during a preparation time. Both types of training are important and are vital to the success of the program.

Teachers need to be aware of how students learn and be comfortable with methods of teaching with manipulative materials. They need to know how to set reasonable goals and objectives for their own classes and how to use inquiry methods to develop logical thinking skills. Inservice deals effectively with these as well as with management of materials. Inquiry skills and a positive attitude toward themselves, their students, and the environment are essential as well. A knowledge base in the science area is very valuable but can be picked up through the kits rather than inservice.

Since the kits include a wide variety of activities, the teacher is responsible for selecting from among those activities. Sometimes teachers add additional activities appropriate to the class. And, although the materials in the kit are gathered for the teachers, the teacher is still responsible for any last minute preparation and the distribution of these materials to students. We know they can do it because support and inservice in the instructional area are available through other teachers, the science resource staff, and the teacher's principal. A visitor to one of our elementary science lessons would see the teacher:

* **Distributing** materials to students

* **Working** with students on an individual or small group basis

* **Questioning** students about what is happening in their experiment

* **Leading** students to develop possible theories

* **Recording** whole group data

* **Sharing** small amounts of factual information or specific experiment direction.

* **Leading** class discussions

* **Listening** to students

* **Supervising** students through processes

* **Helping** students clarify their thought processes

A variety of textbooks are used in a supplemental manner in our program. In most cases, these texts have been taken apart and rebound so we have books like we want. A particular kit can include a variety of different chapters on the same topic allowing for independent or group reading. Specific student workbooks or information booklets for some students have been developed by the district as well. These are consumable and are meant to be taken home, allowing parents to become involved with the science activity. Also, parent volunteers are used wherever possible to assist in the hands-on aspects of our program. They are absolutely essential to the environmental camping experience.

Video equipment is very important as a supplement to our kits also. The district has a 16 mm film library and each teacher is given a listing of the films most pertinent to the kits at that grade level. The kits frequently contain a filmstrip cassette supplement appropriate to the topic. Whenever possible, outside speakers are recommended in the teachers manual for the kit. The teacher can receive help in scheduling this speaker through the district career specialist.

We feel strongly that although the processes of science may be somewhat sequenced, it really makes very little difference, in most cases, which content area at a given grade level is covered first or last. The student who has the weather unit before the electricity unit is at no real advantage or disadvantage to the student who has them in the other order. In both cases concepts developed in the first unit can be used to enrich the second level. This flexibility of sequence allows kits to be widely used throughout the year.

Our kits have been assigned arbitrarily to a grade level for administrative convenience but, because of the wide variety of activities in a given kit, it could easily be appropriate to the adjacent grade levels. Any school, as a total group, can request that their school change the grade level sequence to reflect teacher interest. Our only requirement is that the request come from the school as a whole and be considered a permanent change and not a one year special occurance. Any teacher, at any grade level, is also welcome to order a kit from a lower grade level since teachers at the lower level have already had the first opportunity to use these materials. An average minimum time of 70 minutes each week for primary and 90 minutes for intermediate is required. Counting all the time that science is integrated into other subject areas, this time is usually greatly exceeded. Quality is more important than quantity. However, through integration through other subjects, we hope each student will be involved with science every day. Activities vary widely in the amount of time they require. but probably average about 2 1/2 hours per week at the primary level and 4 hours at the intermediate level.

EVALUATION

Teachers are responsible for the day-to-day evaluation of students, program, and self. Both principals and district personnel do periodic evaluation in these areas as well. We would like evaluation of students to stress the use of science knowledge but this is a most difficult goal to implement since it makes paper and pencil tests more complicated to develop. In some cases, actual written problem solving tests have been created but, more often, teachers use direct observation of students dealing with these types of problems. Right now, Numerous simulation activities have been incorporated into the kits in an attempt to provide this type of evaluation. Students are evaluated through observation, simulations, problem challenges and traditional tests.

Since our program began, the standardized test scores on the Sequential Tests of Education Progress rose from 47% in 1977 to 64% the last time the test was given in 1981. Our students' willingness to volunteer for community work projects also has increased significantly. Our superintendency and the general public have been impressed, although this was not our goal, by the rise in the standardized test scores. Both longitudinal studies and surveys of past graduates are under way through the district research and evaluation department as well as a joint project between our resource center staff and the elementary education department at Arizona State University. We are looking forward to using the results of these studies. Teachers are periodically evaluated by the building principal. If help is needed in the area of science, the resource teacher for that school is contacted by the building principal. In rare cases, the resource teacher will make the first contact with the principal to discuss a teacher's need for science inservice beyond that available to all teachers.

Update sheets, completed by teachers, as well as the periodic revision of our units by our resource staff, allow most of our kits to be more up to date than the traditional text approach. Members of the university community meet with us periodically to review research and the implications for learning which we can apply in our setting. Additional evaluation of our program has been provided through our junior and senior high school teachers who are highly enthusiastic about the increased interest and process skills demonstrated by our students at those levels. We are also delighted that student volunteers for ecological school activities have risen 40% since the beginning of the program.

In addition to the evaluation sheets that the teachers fill out for every kit, the science component of the elementary school is reviewed periodically at each school as we look at six major areas:

SCHOOL SITE

1. Does the school have the basic science kit available to all teachers?

2. Does the school have an outside learning area where appropriate science activities can be carried out without interferring with other activities?

3. Does the school have a convenient place where units being picked-up or delivered can be safely kept?

4. Is there a member of the school staff who takes responsibility for delivered science materials until they are picked up by the appropriate teacher?

TEACHER PREPARATION

1. Are teachers familiar with the scope and sequence objectives relating to their grade levels?

2. Do teachers contact the Science Resource Center when they teach a new science unit or reteach a unit which was not highly successful?

3. Do teachers request almost all of their science units at least ten days before they are needed?

4. When student interests move away from the teacher's outline but within the general topic, does the teacher make adjustments in the unit plan?

5. Does the teacher have the science materials cleaned, neatly packed, and ready for pick-up?

6. Do teachers have a year-long science program of at least four science units including at least one biological unit, one physical science unit, and one earth science unit planned for their class?

7. Do teachers have a year-long health education program which uses kits, texts, and projects to promote positive health awareness?

SAFETY

1. Are proper safety measures taken whenever each of the following is used? Fire, Glass, Animals, Chemicals, Electrical Materials.

2. Do the children demonstrate an awareness of the need for safety in a science classroom?

3. Within ten seconds, can the teacher gain complete attention of students?

INSTRUCTION

4. Are a variety of hands-on experiences used?

5. Do students intellectually manipulate ideas as well as physically manipulate materials?

6. Is the teacher more likely to be in the role of a guider and questioner than an information giver?

7. Is reading in science a procedure for extra exploration or information seeking rather than the core of the science program?

8. Do students do independent library research related to science?

9. Is adequate instructional time spent on science?

10. Are plants and animals well cared for?

11. Are outside speakers representing various science related careers part of the instructional program?

12. Do teachers assist students in recognizing the relevancy of science concepts to daily living and to possible future career areas?

DISTRICT SUPPORT

1. Is the support from the Science Resource Center adequate in the following areas? Delivery System, Unit Content, Equipment, Unit AV Support, Training, Special Requests

STUDENT PROGRESS

1. Do 80% of the students reach the individual unit goals set by the teacher?

2. Do 80% of the students reach the district goals for their grade level?

This constant evaluation at all levels combined with continual revision insures relevance, permanence, and that science will be taught.

Responding to community change is a difficult challenge but having the kit-type format allows traditional update sheets related to community problems to be added at any time. The community student profile is not necessarily changing although it may shift from one component to another at a given school. The flexibility of the student activities in the kits helps teachers to adjust to this change. Resource teachers are also very sensitive to this type of shift and work with teachers on a one to one basis. Resource teachers frequently substitute in the classroom so that the teacher can make visitations with a master teacher in a similar situation. We are working to incorporate even more experiences where children attempt to solve real problems. The more meaningful the experiences, the more we believe they will lead to student growth and understanding. The district level administration provides both financial and moral support for the program. The school administration provides leadership motivation and support for the teachers.

In hiring teachers, Mesa's personnel department uses a commitment to human welfare and progress as one of their screening instruments. This is not a problem with the vast majority of our teachers but, when it is, the resource teacher and principal of the school work together to produce change. This support is vital. Our support model calls for a district director and secretary plus one science resource teacher and one science clerk for each high school and its feeder junior high and elementary school (approximately 10,000-11,000 students.) The resource teachers are responsible for curriculum development and teacher training. The science clerks are responsible for ordering and maintaining materials used in the science kits. Most administrators in our district are supportive team members as well. They are viewed by their teachers as mentors more than evaluators

Costs for the 82-83 school year including the salaries for all staff members of the science resource center and all new materials purchased, both consumable and supplemental, works out to a cost of $2.89 per pupil for the 29,000 elementary students. As we continually revise kits, we become more optimistic about what goals we can cover. In the first kits we attempted to provide hands-on manipulative kits for students. Since then, we have moved on to include career education and problem solving goals. Now we are attempting to make our kits even more responsive to local community issues and to provide evaluative techniques involving higher levels of thinking.

Input from professional organizations has been vital in updating us on science trends and current research. It has also been important to know that others in Arizona and nationwide share our concerns. I believe every elementary school library receives a copy of **Science and Children.** Other professional journals are used heavily in our junior and senior high programs but **Science and Children** is definately the most widely read and useful journal at the elementary level.

In our district teachers have to use the program. The resource teachers have the responsibility of seeing that they use it most effectively. Teachers from other districts have begun to use similar programs or components of ours following on site visitations to our resource center. We have worked with teachers from many other districts. We are presently working toward developing units that integrate directly with other disciplines by involving students in broad problem areas. I hope to see additional movement in this direction.

If we wanted the program to fail we would reduce or eliminate the number of science resource teachers and give every teacher a classroom set of science books. But, if you wanted to establish our program in your district, a visit to a resource center would be really important. Once a district had made a commitment to the program, I would advise them to be sure that an appropriate inservice component was available and not to attempt an overnight implementation of the program. A district should allow for a gradual turnover to the new program as teachers became trained and comfortable.

The biggest rewards for teachers is students reacting positively and successfully to the science kits. Teachers also seem to appreciate that much of the gathering drudgery has been done for them allowing them more time for planning and teaching lessons and communicating with parents. Several Mesa teachers have received recognition throughout the awards program for outstanding elementary science teacher given by the Arizona Science Teachers Association. Teachers who have been recognized by this group are Perry Montoya, Norma Herbold and Joan Goar. Other teachers have been asked to present workshops at state level science meetings. Virtually all of our resource teachers have done this as well.

Our program was inspired, developed, or supported by:

Dr. Gerald Mikesell: Original Director, Mainstay and Inspiration of the Program

These members of the superintendency have provided strong support for our program:

Dr. Jim Zaharis
Dr. Doug Barnard
Dr. Doug Vance
Dr. Susan Sprague: Present Director and original resource teacher

Sarah Baldwin
Norma Herbold
Jerry Sweitzer
Charles Cooper
JoAnne Wolf
Ruth France
Bob Box
Tom Shuster
Bill Smith

Teachers who served in the rotating role of resource science teacher. Their vital leadership developed our kits, trained teachers, and produced special projects such as environmental education days, school camping, and career project.

Chapter 8: Elementary Science

By

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Ames Community Schools
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Located in central Iowa thirty miles north of Des Moines, the state capital, Ames is ninth in size in the State of Iowa with a population of 46,000. The city serves as a retail center for a population of 70,000. Iowa State University, with an enrollment of 24,000 and staff of 7,000, is an integral part of the community performing major functions in the areas of teaching, research and extension; and providing a broad range of educational, cultural and athletic programs and opportunities for the community.

In 1974 87 percent of the people age twenty-five or older had completed twelve years of school and 44 percent of those over twenty-five had completed four years of college. Almost two-thirds of the persons included in the civilian work force were employed in professional, technical, managerial, or administrative occupations. More than one-half were employed in government positions. It would be reasonable to assume that those figures are still representative today. The median family income in 1974 was $10,126, but is estimated to be over $20,000 now. A recent Community Development Survey indicates a projected steady growth for Ames with emphasis on the city's potential as a cultural and convention center, as well as a growing health care center.

The school district has an enrollment of 4,800 with teaching staff totalling 290. Facilities include eight elementary buildings, two junior high buildings, one senior high, and one special education facility which serves thirteen communities in addition to Ames. The school district has been among the highest spending in the state and continues to enjoy good community support. Ames students are well above average, with achievement levels on standardized tests constantly showing grade level averages above the 90th percentile level. Specifically, the Iowa Tests of Educational Development results for grades nine and eleven in 1982 found our mean scores at the 99th percentile on national norms on every subtest and the composite. Class size varies with an average of approximately 24 at the elementary level and virtually none above 30.

Having class sizes that average 24 students, some of whom have been mainstreamed from LD, EMR, and ED as well as physically disabled classes, contributes to a heavy burden on the elementary teacher of science. Additionally, TAG students are also mainstreamed, creating further stresses upon teaching attitudes.

The elementary school staff is made up of 104 classroom teachers, 79 of whom teach science, some in departmentalized programs. There are approximately the same number of math teachers serving the K-6 program. A science coordinator assures articulation of the program K-12. One special feature of the program is our outdoor environmental education program which was developed eleven years ago to provide a controlled system for learning outside the classroom. The program has been highly successful and is just one manifestation of the school's concern for science education for all youth. Another unique feature is the Ames High Prairie, a twenty-eight acre living laboratory near Ames Senior High School that is used by numerous elementary classes for field trips and ecological studies. Elementary teachers also use the city parks that are within easy walking distance of nearly all eight elementary buildings.

Our "old" science program consisted of **SAPA-II** modules for grades K-3 with **ESS** and teacher prepared kits for grades 4-6. In addition, some teachers were still using the 1962 text, **Concepts in Science**. Since our program lacked a scope and sequence other than **ESS** kits being scheduled on a six-week rotating basis and 15 modules of SAPA-II being assigned to each grade level, teachers really did not have a good perspective of what was to be taught and at what grade level it should occur. The program was taught extensively by some teachers, less by others, and some for a variety of reasons did not bother with the kits. On paper it was supposed to be a district-wide program, but in practice it was more likely to be accomplished in select elementary building and classrooms.

While the prior program was supposed to be a "hands-on" approach to science, through classroom visitations and personal contacts the science coordinator, along with building principals, was able to ascertain that "hands-on" science was in serious trouble in the science curriculum. If little or no science was being taught in a particular class or an entire elementary building, then we would be hard-pressed to say that classrooms at the intermediate level were really self-contained.

One result of our new program is that there is more departmentalizing in grades 4-6, enabling us to strengthen the confidence and backgrounds of fewer elementary teachers while improving science education in more classrooms at the elementary level in Ames. A teacher preparing one unit for three classes appears to be more effective and efficient than if each teacher prepares their own units. Self-contained classrooms were, in our opinion, one reason for the limited use of kits for activity-based science and was a result of teachers not really knowing and understanding how the kits were to be used. More science specialists helps us solve this problem.

With the lack of a scope and sequence, science in the elementary schools of Ames allowed for a great deal of latitude on the part of teachers. Furthermore, not having any definite time allotments for the teaching of science at various grade levels gave teachers a great deal of discretion on what the curriculum should be and how they would teach science. This type of teacher flexibility led to numerous gaps in an elementary student's science education. Some teachers, arbitrarily or otherwise, omitted science from their grade-level curriculums.

The need for a new program did not really become apparent until the concerns of teachers were finally heard after numerous visits to elementary science classroom by the science coordinator. Over and over, teachers were saying, "Give me some help." If you asked them what kind of help they desired, they would invariably say, "Give me some guidelines on what to teach, how to teach science, and find us some material that enhances or encourages the use of **SAPA-II** modules or **ESS Kits**." It was not that they didn't or couldn't teach science, rather it was that they felt a need to know what should be taught and for what grade level it was best suited. This lack of teacher confidence in teaching science surfaced many times. Elementary principals were also being pressed by their teachers to give them some assistance with the science curiculum. So, we held a series of grade level meetings to discuss their concerns, needs and ideas. Numerous sessions involving curriculum mapping were used at this point.

Knowing that students were being shortchanged in their science education was an important factor for Roger Spratt, the science coordinator, desiring to improve the science curriculum for all students. Having classroom teachers constantly saying, "Give us some guidance and help," provided additional impetus to make some changes. Finally, a few teachers began to say, "We will help make changes if you will help us use the resources available to us." A better understanding of the teacher's time dilemma also contributed to the desire to improve our science curriculum K-12. We have constantly expected teachers to teach more curriculum in many areas without really providing the time for it to succeed. Streamlining our curriculum thus really became a necessity rather than a luxury.

PROGRAM DEVELOPMENT

Many teachers had a large part in the development of new curiculum for elementary science. Dr. Luther Kiser provided the background for our curriculum mapping efforts as well as giving us suggestions for a timeline to complete our science curriculum revision. Further, he explained what some of our parameters might be with this task. He provided guidance on such items as time, finances, current material available and specific teacher talents critical to this task. The science coordinator's classroom visits, teacher-to-teacher contact, and a small group of teachers wanting to improve the program all served to provide the initiative for making changes. Understanding the teachers' concerns in light of their respective classroom situations also played a major role in setting the stage for improvement in the science curriculum.

We spent almost one semester mapping our curriculum, trying to determine what was or was not being taught. Concurrently, we also were developing and updating our K-12 science philosophy to have it parallel the school district philosophy. This developmental process involved the classroom teachers extensively. Much of the work was done through the K-12 Science Vertical Committee and subcommittees specifically staffed by elementary personnel. This vertical committee has representatives of every grade level, a principal, and the science coordinator.

Our assistant superintendent, Dr. Kiser, spoke to our vertical committee on the basic process of curriculum development. Then the State of Iowa Science Consultant, Dr. Jack Gerlovich, led an inservice session using the Science Curriculum Revision Tool developed by teachers in Iowa. Using portions of this curriculum tool, we then began to determine a beginning scope and sequence for our K-12 science program. As a result of these efforts it was decided the most serious problem was at the elementary level of instruction. Thus, we completed our philosophy, set three major goals, and determined the objectives for the respective grade levels. Then we set out to investigate what materials might solve our problems and lead to our goals.

Our administration provided encouragement by funding inservice time and by providing staff meeting and curriculum writing time in the summer months. They also seemed to understand the current needs of science education in the school curriculum. The science coordinator met with all eight elementary building principals to discuss what type of program we should pursue. By unanimous agreement, they decided to retain "hands-on" science while blending in appropriate print material. They each agreed to spend one day themselves on inservice training with the new program prior to the inservice day provided for teachers. In August, 1982, they spent an additional two hours learning about new nutrition materials that were written during that summer. Their continued willingness to call upon the services of the science coordinator when they perceive a problem in science instruction is an added bonus illustrating their continued support.

Inservice meetings for K-6 elementary teachers of science were scheduled upon completion of each writing team's materials. Science vertical committees continued to meet and a K-6 subgroup was established for other meetings. We established procedures ordering and receiving consumable materials and began an elementary science newsletter, **The Compost**, for written communication to teachers in the classroom. This provides continued assistance with the teaching of science.

Perhaps the uniqueness of our program is that so much of what we did was for teachers first, and students second. Although this might seem like we are not concerned about individual children, the exact opposite is true. From the beginning we recognize that to bring about change in science learning, we would first have to bring about change in science teaching. Therefore, our primary goal was: What can we do to help motivate teachers to feel comfortable to teach science? It seems to be rare to find the majority of elementary teachers as comfortable teaching science as they are teaching reading. Therefore, we felt our program must deal with teachers as well as students.

OUR PROGRAM

For the most part, we have excellent physical aspects for all classrooms. The major disadvantages would be that many rooms are very small and lack storage. For this reason, a major part of our program, which was the development of the guides, has eliminated piles of clutter and disorganized supplemental materials. The procedure for ordering supplies and materials is excellent. The materials and equipment can be in a classroom only when they are needed and then sent to other classrooms. When not in use they are housed in a central location for the district. Each teacher has activity-based kits available, but does not need to provide storage. Classroom sets of texts are kept in rooms for grades 3-6. Consumable lab materials related to use of the text can be ordered in advance and kept in the classroom as well. Individual teachers have the option of having aluminum foil, straws, vinegar, and other supplies stored in their rooms or delivered specifically for a particular unit or lesson. The clasrooms are not really unique--just the guides and central organization of materials.

Kits aid in that organization. By having kits, teachers avoid wasting time doing preparation for science class lessons. For example, Unit 4/7 is about oceans. The guide provides a map of the world's oceans saving individual teacher time. Most fourth grade classes now have a reproducable map of the oceans. This does not mean every fourth grade teacher will use it, but if needed it is there. The kindergarten science guide contains an activity on habitats. Most primary teachers do have pictures of animals, but it is sometimes difficult to find the exact pictures you want or pictures of the exact size you want. Now, they have them. Many of the worksheet pages in the first grade guide for science were correlated with other disciplines. For example, the worksheet on the "Senses" activities correlates with the first grade reading program. Math skills are also correlated. The guides are being used because they are helpful to teachers and motivating for students.

Each elementary school has a media center which is equipped with film projectors, filmstrip projectors and computers. Each science guide has a film review sheet to encourage gathering of information on films for discussion purposes. Staff members are involved in computer classes so that more use will be made of these resources. For example, in the 6/Nutrition writing done this summer, reference was made to a nutrition program for the computer. Not all schools have the same software, but the direction is given for teachers to view the possibilities and use them with their classes. We chose a text to provide a skeleton or framework of learning on which we can base all other learning activities and experiences while the science guides provide clarity and conciseness aiding teacher preparation. If the students study "astronomy" for several years, what different content will they have in fifth that they didn't have in fourth grade? Thus the guides reinforce the sequential growth of learning but still permit flexibility, such as use with our classes which are multi-aged.

Further uniquenes comes from the organization. If we change texts, many of the guide activities can be quickly recoded and rearranged for supplemental materials for a different unit or topic. For example, if a teacher wants to use the solar ovens which are available, the teacher might offer experiences during a study of energy or nutrition. If the teacher is working on growth in investigative skills, she might compare solar ovens to conventional or microwave ovens. Another possibility would be using solar ovens to prepare food for a class party. The suggestions on use of solar ovens could be rearranged in the guide, depending upon teacher use and need.

A major task in our program was for the science coordinator to develop the K-12 science budget. This means that the best use of money has been made available to particular schools and classroom. As a result of this, we have excellent materials--including microscopes, human torsos, and balances which are not always in elementary schools. The science coordinator is only available on a two-fifths time basis but does visit classrooms and is available daily for professional assistance. Roger also serves as chairperson of the Science Vertical Committee (K-12), organizes service and maintenance of equipment, and provides direction for staff. We also have a staff member who works part time delivering and returning science kits and other district materials which are housed in a central storage building and are available for any elementary teacher upon request. The science coordinator also keeps materials in good repair so that initial cost is not wasted.

Each teacher has a teacher's manual for the text and a science guide written for that grade level by our district writing team. In addition, teachers in grades 3-6 have clasroom sets of texts and a copy of the text's activity book and evaluation materials. Each teacher also has the option of requisitioning and storing consumable materials for the year. In some buildings this is done by individual teachers, and in other buildings there is a central storage area for science supplies for that attendance center. A request form indicating item and quantity is sent to the science coordinator who supervises the delivery service. From here on, individual teachers handle their hands-on lab experiences in a variety of ways, based on their room assignments, particular students, and teacher preference. Most teachers encourage students to help organize their labs and be responsible for the maintenance and use of their materials. The guides recommend that clean-up be a part of the student's investigative experience.

Our science guides, written by teachers, provide:

***Goals and objectives** for each unit of study providing guidelines for what content should be taught at each grade level, allowing for our diversity of multi-aged classrooms and mainstreamed children.

***Correlation with kits** in a unit of study. Study guides are given for some of the kits. In other cases, only suggestions to use the kit are given, and teachers' guides are available with the hands-on materials.

***A health summary chart** for: safety, nutrition, dental health, substance abuse, disease prevention, and human growth and development. This chart directs the teacher to other print materials, models, prepared kits, and a variety of sources available through media centers or the central storage building. We have already revised nutrition into a separate section, and have plans to revise the entire health section next year.

Information on the use of microscopes, metrics films, and other cross-grade level information.

Our General Goals are for students to:

Apply science processes as a part of basic learning.

Communicate knowledge of natural phenomena.

Use scientific knowledge in comprehending the impact of science and technology on the individual, culture and society.

In meeting these goals many units focus on human adaptation and futures. For example, our energy Unit 6/7 deals with decision making about energy issues while Unit 6/Nutrition has an activity on world hunger. Sixth graders chose representatives to attend an "I'll never Smoke" clinic. Representatives share information with their classmates as part of Unit 6/1. Unit 6/9 deals with pollution. We have role-playing activities relating pollution to our district's water source. Each guide has information on human growth and development, safety, and substance abuse.

All the activity-based kits and many of the activities in the science guides emphasize inquiry skills and processes. These activities are an integral part of each unit or topic of study. The guides also provide an infusion of curriculum disciplines. For example, observation of animal movement in Unit 5/1 is related to a language arts activity on proverbs of animals, stressing literal and figurative meaning. Unit 5/4 on the human body has an activity on skin and fingerprints. Suggestions are made for a follow-up activity with "unknowns." Unit 5/2 on matter has several activities involving consumer research and recording of data.

The guides provide examples of careers as well. An awareness for the teacher triggers individual activities and experiences. Unit 5/9 on plants has students investigating career possibilities with plants. Unit 6/2 on microorganisms has a deductive reasoning activity which provides insight into the role of workers at the Center for Disease Control. Unit 2/1 has students dealing with viewpoints of agricultural workers. Students have ecology experiences with all-day field trips to nearby facilities and concerns for the environment and environmental careers are dealt with at all grade levels.

Teachers make good use of the local resources in providing a curriculum relevant to our community. Iowa State University provides many opportunities for expertise and activities in the guide stress many experiences meaningful for students of Ames. For example, energy units asks students to figure the electrical rates for our city and monitor ways they conserve energy, encouraging an activity with parent involvement. In another unit, students are encouraged to play "soybeans", using a crop for our area. Unit 4/4 on minerals, rocks, and fossils encourages a field trip to a local area to find brachiopods dating to the late Paleozoic Era. Unit 3/4 deals with simple machines and those used by school workers.

Because the framework involves a text, the curriculum guides are organized around a problem-centered approach rather than a topic-concept core. However, the activities and experiences which relate to the concepts are problem-centered. The continued emphasis on relevant hands-on experience structures the science and provides for diversity and open-endedness. Individual teachers are greatly encouraged to take the students beyond the concept or skill and into applications. "How does this relate to. . ." is a major part of our science program.

Our classrooms at the elementary level include students mainstreamed from mentally disabled rooms and emotionally disturbed self-contained classrooms. Talented and gifted student and learning disabled students are involved in pull-out programs, so usually they also would be in the science class. Students leave for band lessons, speech therapy, and guidance counselor visitation as in any school. For these reasons, the science guides are flexible, providing materials to be used as worksheets, learning center materials, lab station references, make-up, and work summaries. The guides are extremely helpful in reducing teacher preparation time so that direct contact can be made with students. Lessons include optional and related learning experiences to meet individual differences.

Teachers are encouraged to provide a variety of learning experiences and activities were written so that the materials in the guides could be used in large or small groups or with individuals. However, the organizational pattern for the teaching method is as diverse as our teachers. Many of our teachers felt the "alphabet curricula," such as our **ESS Kits**, by themselves did not always coincide with our understanding of Piagetian Psychology. We feel our "new " program better meets all developmental areas of our children. Of course this must be assessed by individual teachers. We do feel strongly that we are working toward our General Goals and our more specific Educational Goals. Our Educational Goals include enhancing student:

Confidence

*from a feeling of self-worth
*from having pride in work well done
*from self-discipline
*from experiences in physical activities

Competence

*in reading and arithmetic skills
*in skills of communication of information, ideas, and feelings
*in use of concepts and ideas of mathematical, physical, natural, and social sciences
*in ability to interact with other people and with the total environment
*in ability to gather and to evaluate ideas and information from a variety of sources
*in ability to apply knowledge and ideas both to new and to routine situations
*in one or more individually developed talents, interests or skills

Compassion

*to listen with understanding to ideas of others
*to respect associates at home, at school, everywhere
*to understand and respect persons with cultural differences
*to be sensitive to the needs and desires of others
*to be aware of the effect of actions on our physical and natural environment
*to behave responsibly

Curiosity

*for always seeking information and ideas--for lifelong learning
*for questioning ideas and conclusions of others
*for understanding the effects of new events and ideas
*for finding a logical explanation for a problem
*for predicting and evaluating the probable effects of own effort and those of others
*for developing interest in the arts and humanities

Creativity

*in imagining better ways to meet challenges
*in developing a new synthesis of skills and ideas to express feelings
*in combining ideas and information to extend knowledge and compability

From the beginning, we recognized that to meet these goals and to bring about change in science learning we would first have to bring about change in science teaching. Therefore, our primary goal was: What can we do to help motivate teachers to feel comfortable teaching science? Our program is designed to provide a variety of activities to encourage teachers and students to apply information towards various scientific, personal and social concerns. Further, the curriculum evolved in the correlation of science education with other learning experiences which children have throughout their school day and beyond.

The content includes concepts covered by the texts as well as processes and skills developed through activity-based lab experiences. We believe the factual concepts contribute to an organized scope and sequential approach to science learning, while the kits provide opportunity for growth in problem-solving skills. Through other activities, such as ecology field trips (project ECO), conservation camp (for sixth graders), and participation in energy awareness days, we are emphasizing a balanced approach to the traditional science disciplines and, at the same time, working towards application of knowledge and skills in resolving relevant, science-social issues.

In most cases teachers are the planners of the lessons while "Where have they been and where are they going" are the responsibility of the district and implemented by the teachers. However, individual lessons involve a variety of student participation and input. Labs provide the opportunity for students to organize their materials, control and manipulate their variables and record their data. Viewing films involves discussion afterwards. Satellite areas of study or divergent paths to be pursued are initiated by either teachers, students or both. Individual students are evaluated twice a year on progress in areas such as relationships to peers, relationships to adults, control of behavior, direction of learning, use of class time, and self-control in formal and informal situations. These areas certainly suggest that the district encourages teachers and students to work together in teaching/learning task organization, commitment and evaluation.

Teachers are encouraged to do their own planning and organizing of science experiences to meet the needs of their students. The teacher who is less confident (or who has more preparations such as in a self-contained classroom) or who is teaching a particular grade level for the first time will probably use the science guides a great deal. The more experienced teacher will use the guides as starting points for units, but adapt for both teacher and students needs. For example, the teacher may think, "Oh, great. This gives me an idea. However, I want to combine these two worksheets and add an activity that I've been thinking about." That teacher would then produce a related experience that had a foundation in the guide but was made better. The beauty of the whole system of the guides is that they are designed to be added to and taken from, as well as organized to encourage further organization. Worksheets are coded for easy access.

Three-ring binders with papers written on only one side provide for easy filling by topic. The guide is not the curriculum through; our curriculum is the dynamic interaction of a conscientious teacher, the ideas in the guide, and a classroom of students.

Inquiry methods are necessary to the strategy of our program and we continually reinforce that strategy. The use of experiences in reality, of hands-on experiences, of group sharing as well as independent study are all important to the program. We look for every opportunity to provide multi-sensory and multi-source learning experiences in our elementary science program. We want teachers to ask questions which stimulate and provoke. Student responses should be accepted without evaluation as we want students to initiate ideas, questions, and learning.

If you visited our classrooms you would see students doing a variety of activities and having a variety of experienes. They could jointly or independently be dong any of the following: reading from a text, doing a lab activity, viewing a film, having a discussion, organizing a project, sharing a reference, or listening to a speaker. The key would be variety. What you see today would probably be a different kind of activity than on some other day. Some common threads weaving through our diversity would be visible, however. * Students would probably be doing activities related to a similar general topic. For example, if the fourth grade class is studying light energy, some students might be making kaleidoscopes while others are researching astronomy theories. The next day they might all be invovled in the ESS Optics Kit. While the general topic would still be light energy the experiences would have ranged from concept emphasis with reading to a process/skills emphasis with the kit. In addition would be the fun, motivating project of the optical instrument. The next day students might deal with the Braille language and awareness related to concerns of a classmate who is visually impaired.

Individual students would be encouraged to diverge into other areas. The talented and gifted students might use classroom activities as springboards to further learning during their half-day with the TAG facilitator. Other students in the classroom, not specifically identified as TAG students, also have opportunities to plan and carry out related activities. Some might choose to use light energy topics in creative writing or investigate solar printing.

Most of the student activities would have been suggested in the teacher's manual for the text, in the activity-based suggestions, or the district science guide. However, not all would be. Teachers are encouraged to use related activities and learning methods which meet their interests and abilities, too.

On a daily basis teachers will be doing a variety of things as well. Sometimes they are setting out lab materials; other times they are listening to discussion, showing films, giving instructions for long-range projects, setting guidelines for a group activity, asking questions, giving answers, or trying not to give answers!

The teachers let the students do much of the doing. In this aspect the teacher is much more a facilitator of learning than a dispenser of knowledge. The teacher may decide that a debate on alternative energy sources is a meaningful activity for a class but the students do the activity. Although the teacher might have materials available in the classroom for reference, students are encouraged to find much of their own information. There are a few discipline problems with students working together, a few interruptions at the door, and a few students absent. There are also a few students who are showing more positive leadership, using research skills who never did before, and many students who say, "This is neat. Can we do this again?"

Teachers avoid doing the same thing every day. The textbook is not meant to be used as a "read, write, read" kind of learning. The science guides provide a wealth of suggestions for "doing" kinds of activities. Creative dramatics, art, movement, math, and interviewing are all invovled with science as the focal point. Science thus becomes a search for knowledge and skills, not just a closed pathway through the known facts. Time for science is very important. It is not so important to know how much time is allocated for science instruction as it is to how effectively we take advantage of the time available. If we minimize the amount of preparation time needed by individual teachers, we tend to maximize teacher effectiveness in our science classes. This reduction of preparation time leads to more time and greater teacher confidence in the teaching of science; consequently, more teachers feel comfortable in teaching elementary science. We recognize that there is a wide range of teacher competency and interest in the area of science teaching at the elementary level. The establishment of our improved program capitalizes on the strengths of our teachers and students and works for ways of making science experiences meaningful to all.

New teachers in our program need good management skills and an interest in organizing ideas, materials, and equipment for effective educational delivery systems. They should have training in a wide variety of teaching skills and strategies. For example, they should have some background in developmental psychology as well as experience with discussions and questioning techniques. Ultimately, they should have interest and confidence in their professional abilities in teaching science. We believe that confidence comes as a result of knowing that there are vast amounts of resources available to assist teachers in the teaching of science. In other words, they should be able to make use of whatever resources they need to get the job done efficiently and effectively as shown by student outcomes and successes.

Health/Science teachers follow each of the seven curriculum guides (K-6) in organizing science experiences for their students. While time spent per week varies, suggested district time allotments are:

Grade K

No allotment listed; science experiences continue to be woven into all the children's activities.

Grades 1-3

100 minutes per week for specific instruction, with interdisciplinary activities encouraged.

Grade 4

150 minutes per week for specific instruction, with interdisciplinary activities encouraged.

Grades 5-6

200 minutes per week for specific instruction, with interdisciplinary activities encouraged.

The time schedule for health/science was a joint decision of the teaching staff and central office administration. Thus, it was not a decision handed-down but rather a truly shared commitment for time for all curriculum areas. This sharing continues to encourage the full participation of the entire K-12 professional staff. Seeing their input bear fruit satisfies their need to be heard in decisions that affect the clasroom. The time allocated for each grade level is more than in most districts and allows for a greater variety of materials to be prepared and for expectations to increase and reflects a definite commitment on the District's part to include significant health/science curriculum in a student's education.

EVALUATION

Student interest is positive. Although our new program has not been in effect long enough to indicate changes which could be reflected by academic scores or standardized test results, students continue to select science as an area of study. Students are on a non-graded system in elementary and a graded system beginning in junior high. Science is required in grades 7, 8 and 9, and optional in 10. About 90 percent select biology in tenth grade, although it is not required. Approximately 50 to 60 percent enroll in physics, 50 to 60 percent in chemistry, and another 25 percent in physical science.

Program Evaluation is one of our next major tasks, we often ask, "Are we really teaching what we had planned to teach?" This we hope to discover by developing some criterion-referenced tests and by some in-depth usuage of standardized tests such as the **Stanford Achievement Test** and the **Iowa Test of Basic Skills**. Using item-analysis of these tests will, in part, aid our evaluation task.

Two parent/teacher conferences are held each year with narrative evaluations written and shared for all curriculum areas. Students are also given unit "tests" by teachers in the upper elementary grades. Since conceptual and skill learning is an ongoing process a following activity would result in information about whether or not a student can apply what was introduced in a former activity. Some teachers use the evaluations which coincide with the texts while others write their own tests. Many teachers do not give formal tests. Our elementary program is non-graded, with narrative evaluations writen twice a year. Many teachers, particularly at the lower elementary level, do non-written evaluations. Written evaluations include evaluations not only in the area of concepts, but also in use of problem-solving skills and study skills. These include observing, recording, reasoning, contribution to discussions, use of references, and use of time.

One of the weaknesses in our current program is that we have not yet developed any criterion-referenced testing. If you investigate student learning based on national standardized tests and national and state norms, you would find that in the past we have achieved very high scores, usually in the 90th perentile or higher. But these tests do not necessarily reflect the success or failure of our new program, since they generally are based on curriculum information--goals and objectives-- that may be several years out-of-date.

Our school district is trying to improve computer literacy for all professional staff, and this may well result in the staff being able more effectively to monitor standardized or criterion-referenced tests for the improvement of instruction. Immediate feedback from various tests is crucial to the implementation of revisions in any program. It is highly important, though, that each classroom teacher develop tests that adequately evaluate the material covered in their respective classrooms. Program tests by themselves are not sufficient to evaluate what students may or may not have learned for any particular set of objectives.

Teachers are evaluated for administrative purposes by the building principal. Their instructional ativities as well as setting are assessed on a biennial basis. Because we have a negotiated master contract with a specific teacher representative group, members affiliated with that group cannot evaluate other teachers. If there are concerns relative to the implementation of the science program that come to the attention of the science coordinator or vertical curriculum committee members, that concern is referred to the building principal and that individual's observation is the basis for an official evaluation. The science coordinator fulfills a major role in terms of class visitation and the knowledge of supply use by staff members. In addition, the vertical curriculum committee, with its monthly meetings, serves to keep concerns relative to implementation visible to all staff members. Minutes of that vertical curriculum committee meeting are shared with all building principals and teaching staff, maintaining an awareness of concerns on a regular basis.

SUPPORT MECHANISMS

Central administration has made very clear both through comments and action that instruction in the elementary science program is very important. A part-time science coordinator has been provided as has the vertical curriculum committee structure for the maintenance of communication relative to science. Tangible support can be seen in the provision for summer writing time for the committee of individuals who developed the science curriculum guide. Building principals have shown their support through taking inservice training on two different occasions as the new science program was developed. This training was provided prior to the time that teachers who were implementing a given program received their training. This allowed the principal to be knowledgeable and supportive when teachers returned from their inservice sessions. Principals were made aware that this program required more work of some staff members, so their support was essential for the successful initiation of the program in the buildings.

The administration has also supported us through a Projet ECO teacher who drives the bus, maintains two laboratory equipped semi-trailers, and assists teachers in instruction for three ecology field trips each year for grades 1, 3, and 5 and other grades when scheduling allows. An Administrative Advisor to the K-12 Health/Science Vertical Committee organizes an annual one or two-day environmental experience for sixth graders with optional overnight camping experiences. Classroom teachers provide leadership and community resource people assist.

Professional organizations, especially through publications such as **Science and Children**, **The Science Teacher**, **The American Biology Teacher**, and **The Iowa Science Teachers Journal** suport us as well. We currently have subscriptions to **Science and Children** in all elementary building media centers. The fall conference of the Iowa Science Teachers Section of the **Iowa Academy of Science** and regional and national meetings of **NSTA** have also assisted our program development.

The fall conference of the Iowa Science Teachers Section of the **Iowa Academy of Science** provided access for teachers to see new print material available as well as the opportunity to exchange ideas with other elementary teachers in Iowa. Our local Area Education Agency capitalized on our new program and held a workshop specifically for teachers of elementary teachers in the spring of 1982. This same agency held a shortcourse on Science/Technology/Society in the spring of 1983 for area teachers. Our system played an important role in the development of this shortcourse.

As financial resources become more limited, there will be a tendency to become static. Thus, it will become increasingly important for organization such as **NSTA** and the **Iowa Academy of Science** to provide leadership in the maintenance of a dynamic science program for all children. Teacher involvement in these and other similar organizations will be critical to continued improvement of the science curriculum Doing more with less will be a terrific challenge, but many changes in eduation have resulted from difficult economic periods.

There is no formal involvement by parents in the science program specifically. However, because Ames is also the location of Iowa State University, many parents are also faculty members and share their expertise as guest speakers. Parents are asked to help chaperone the ecology field trips and to help supervise the sixth grade conservation overnight camping experiences. Parents are extremely supportive of science and education in this community and the elementary schools encourage this contact. Parents not involved in the university also act as resource people for various units of study and topics of discussion. Attendance center parent-advisory groups and positive communication through media help parents and schools work together.

AN EVOLVING PROGRAM

Since the science guides were written, we already have had another writing team prepare materials on nutrition. The next objective will be to update the health area of the guides. Following that, we might develop sections on energy or computer software. However, the guides offer the format for future adaptations or adoptions. The Science Vertical Committee is also an indicator of what needs changing and how. Members have expressed the need for mini-workshops on a particular topic, such as electricity or space exploration. We hope we will do more with **The Compost** as a means of encouraging teachers not on the past writing teams to write up an activity or learning suggestion that has been class-tested and submit it to the district to be shared for all attendance centers. Teachers have asked for more grade level meetings to share concerns for integrating or infusing the curriculum. The organization of the guides is being seen as a necessary management part of teaching. Many teachers are asking for a similar coded organization for language arts and social studies.

The science program can easily change with student need. It also is a foundation to meet teacher need. There is no way it can fail as long as it instills more confidence in the teacher and more searching on the part of students. It is basically a program that can meet teacher and student needs because it provides both framework and flexibility. It encourages---by its design and management--involvement, investigation, and interest. Our program would fail though, if we were to stop monitoring the program and remove the K-12 vertical Health/Science Committee structure. Eliminating the position of K-12 Health/Science Coordinator while removing the obligations of elementary principals in visiting elementary classrooms would also do great harm. Our science aide, delivering materials and equipment, is also critical. Subscriptions to professional journals such as **Science and Children, The Science Teacher** and **The American Biology Teacher** would also lower our quality as would eliminating funds for the purchase of new print materials and equipment. We would also have trouble if class size at the elementary level increased much beyond what it is now.

Our teachers feel that with declining enrollment in our area that class sizes may have to be increased. The science program will certainly aid reassignment of teachers and classroom teachers who continually find the demands on the elementary teacher to be, at times, overwhelming. Helping teachers budget their planning time is literally saving dollars as well as meeting more student needs. However, smaller class sizes, particularly at attendance centers where there are mainstreamed students, would allow for more to be accomplished. Although rooms are adequate, much more flexibility in kinds of learning experiences is possible with a larger room, better storage, and empty "nooks and crannies" for small groups to use.

More inservice is needed for our teachers to grow in use of questioning and inquiry techniques for higher level thinking skills. Testing should not just be recall and we need to do more with criterion referenced testing. This year a comparison is being made between two kinds of standardized tests. This type of information will provide greater insights as to future needs.

Project Synthesis had not been developed when we were starting our guides; we would like to emphasize these goals more. We feel we have a tremendous start with the concepts and process/skills, but we need to carry it much further--with better application to a human/issue-oriented curriculum. We need to evaluate our talented and gifted program and provide more for the special education students in our classes. We are aware of areas in which we are weak, and need to provide financial support for continued development.

Our science vertical and a special health committee also will be looking at health texts for possible adoption to update our health portion of the science curriculum. Some teachers have asked for more models to be used in the district check-out system. Money needs to be allotted again for consumable materials and supplies. All budgets will probably be cut this year, but we need to encourage experimenting and lab investigations and often supplies are needed.

We hope to continue to strengthen elementary principal's leadership skills and provide them with new science curriculum information on a regular basis. We would like to reduce the number of students pulled out of science classes for special needs or other legitimate reasons. We need a new district policy requiring elementary principals to visit classes for an entire day, one day per week, resulting in a greater administrative awareness of the needs of teachers and students regarding health/science.

One of the major budgetary needs for the next few years will involve some new health/science curriculum print materials and adequate time during the academic year and summer to continue the planned revision and update for all aspects of the K-6 health/ science curriculum. We are in the initial stages of revising our health portion of the curriculum. Several meetings have already been held relative to changing the emphasis from a knowledge perspective to one of "preventive personal health care." The fact that the elementary school nurses are willing to become involved in curriculum revision is another example of how they view our current science program--a program designed for teachers that ultimately and effectively benefits the student learner. Declining resources means that we must continue striving to make more efficient use of those we have. Therefore, it is imperative that we pursue diligently the task of helping teachers become effective in the classroom with student learners. It is an awesome task, but one that will be focused on by the continued involvement of the total professional team.

By providing inservice training for both teachers and administrators when the new science program was adopted, and through continual followup and support from the time of the program's implementation, we have attempted to involve our professionals. Elementary teachers will continue to be involved on the K-12 health/science curriculum team for input to resolve management, material or other concerns, as well as gain professional growth through discussion and involvement. Horizontal grade level discussions will improve various aspects of the science curriculum such as energy, health, technological advances and the concerns of society in general. Teachers will be encouraged by realizing they are not teaching in isolation from each other or the administration. Strengthening the total team concept will result in better educational delivery to the student learner. This all will involve some joint meetings with other curriculum area teams.

The use of building team meetings is another important aspect that has helped to disperse information and to gain feedback from the practicing classroom professional. Much of the leadership for continued inservice training is evolving from the science coordinator and the K-6 curriculum team members. This mutual sharing of concerns and ideas generally leads to progress for all concerned and the K-12 involvement is vital to the future of our program and its specified goals and objectives. The ability to revise our health/science curriculum without having to start from the beginning is also important. Our curriculum guides are designed for constant revision.

Teachers also must adapt to change, for science is ever-changing. It is difficult for some teachers to "give up" a special topic or unit of study. We encourage teachers to change through sharing their interests and abilities, but this must be done without destroying the scope and sequence of the science curriculum. But, teachers should be encouraged to add and delete from the science guides for it is hoped that the guides will encourage greater creativity on the part of the teacher to meet individual teacher/student needs. And, what one teacher learns should be shared with the district. Through inservice, continued written communication, and the process of committees, it is hoped that this growth will continue.

Since our curriculum allows for improvement on a regular basis, we feel that new demands placed on schools by society may be incorporated into our program with a minimum of time and expense. We have the potential of improving instruction for students without having to completely overhaul or upgrade. The system allows for all demands, infusion of new trends or ideas by involving the teaching staff in the entire process. The designing of activities that lend themselves well to other disciplines find favor with teachers because they lead to greater efficiency in the delivery of district goals and objectives.

We are pleased with the development of the program at this point in time, but we also trust that our structure will allow for continual evaluation and development as new information comes to us, either from the scientific community or from the needs of our students. Specifically, we believe that health/science education is a means to an end rather than an end in itself. By this, we mean that student learners should be able to use information, skills, and processes to solve issues that might be a part of their total environment. We want learning experiences to meet the varying needs of specific teachers, student learners, classroom, and attendance centers in our district. Our grade level emphasis is on activities which correspond to other curriculum areas and disciplines. We have developed a coding system for easy access and refiling of pages to minimize teacher management problems and a variety of activities to motivate and stimulte science teaching/learning. The program already includes plans for continually improving our offering of meaningful health/science experiences for all students. It is highly important to our program to continue the use of teacher talents and skills for improvement of the health/science curriculum. Involving teachers in all aspects of curriculum development is crucial to our success.

As a result of the Search for Excellence in Science Education for the 1980's, action now may well result in significant improvement in science during the next decade and beyond. We feel sharing of ideas in any manner possible will be the basic ingredient for the success or failure of science education in the future.

University and college professional staff desperately need to re-establish rapport with public and private school education. Leadership comes from the top--this appears to have been lacking in the past ten to fifteen years. However, there are indications that this leadership is beginning to evolve into a dynamic role. We look forward to a new era of science education leading to improved learning for students; an era in which we expect to provide impact as well.

Chapter 9: Lower School Science

By

Margaret Harrison

Porter-Gaud Lower School
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Charleston, the major urban center of the South Carolina Low country, has an estimated population of 275,000 and all socio-economic levels from extremely poor to extremely wealthy. The city is famed for its beauty--its outstanding colonial architecture, its many restored mansions, historic public buildings and churches, and its lovely gardens. It is an industrial center surrounded by rural agriculture. There is a navy base and an air force base as well as several colleges--The College of Charleston, The Citadel, Baptist College, Trident Tech, and the Medical University Complex. Despite the recession the area continues to grow.

Merger of three smaller, well-established schools in 1964 formed Porter-Gaud, a private, Episcopal, co-educational school open to students of any race, creed, color or national origin. The campus sits on Albermarle Point, a 70 acre site over-looking Charleston Harbor. Seven hundred sixty students attend three distinct interrelated schools--the Lower School (grades 1-6), the Middle School (grades 7, 8), and the Upper School (grades 9-12). Each division has its own administration, faculty, and facilities. All buildings are connected by covered walkways.

The Lower School is further subdivided into the self-contained Primary Division with grades 1-3 and a departmentalized Elementary Division for grades 4, 5 and 6. These divisions are housed in the wings of an "L" shaped building with the principal's office located at the juncture. With two or three sections at each grade level there are 8 primary teachers, 8 elementary teachers, and 2 art, music, and physical education instructors.

The school's physical location offers many opportunities for field studies. There are extensive grassy areas, a memorial garden, acres of **Spartina** marsh bordering the property, and a fresh water pond surrounded by hardwoods. The two soccer fields are excellent locations for nighttime astronomical observations.

The current program began in 1975 in grades 5 and 6 and expanded to include grades 1-4 in 1976. It replaced a typical book-oriented program using the 1972 edition of **Modern Science** by Laidlaw. While our program has changed, classrooms in grades 1 through 3 have not changed. Under the old program, students in 5 and 6 used desks, now they sit five at a table. While grades 4 through 6 used to share a large bookcase for display of scientific material, now there are areas for hands-on materials, balances, boxes of electrical materials, salt and fresh water aquaria, terraria for small reptiles and amphibia, and an observation beehive. Bookcases in 4-6 now hold the texts used at various times during the year as well as field guides and other interesting science books. Under the old program classrooms were quiet places where students read, filled in worksheets, answered questions, watched the teacher do demonstrations, and took weekly tests. Now science classrooms may be very noisy, with students doing experiments, recording work in a journal. and taking fewer tests.

Although teachers selected which chapters to cover and were free to incorporate new material as they are now, our principal recognized that students were not very excited about science. She had heard enthusiastic reports of a laboratory science program at a local school and wanted to implement a similar program. With this in mind, I was hired in 1975 to teach 5th and 6th grade science with the challenge of setting up an innovative elementary science program.

OUR BEGINNING

My sources of inspiration for our program came mostly from my experiences as the Curator of Education at the Charleston Museum. There, I gave lectures and tours, trained guides, wrote a guide handbook, held workshops for both children and adults, ran the planetarium, set up exhibits, and directed a weekly Nature Trailer club which took monthly field trips. Equally significant were my experiences setting up a Title III Laboratory Science Program for grades 5 and 6 at Nativity Parochial School. I modeled that program after one begun by Mrs. Sara Dillard in Clover, South Carolina.

Many of the other exemplary programs cite their science supervision as a critical aspect of their innovation. We do not have the services of a science supervisor although I serve in that capacity for grades 1-4. With a masters degree in Zoology and college teaching experience I find that my strong science background allows me many opportunities for creativity.

In the spring of 1974 I attended a workshop in Clover where Mrs. Dillard explained her Title III pilot program and classroom management techniques. I was impressed with her use of a daily journal and the importance of reading the text only after a first-hand experience with the subject. I also talked at length with Mrs. Alice Linder, our State Science Consultant. She praised the **Elementary Science Study (ESS)** programs and explained how in many cases one need purchase only the teacher's guide, put together the necessary inexpensive supplies from various sources, and use appropriate teaching strategies to have one of the finest elementary science programs available.

In the summer of 1975, after deciding which units of **ESS** would be taught in the 5th and 6th grades, I went through catalogues and ordered the necessary teacher's guides, kits, supplies and equipment. The following summer I went through the same process for grades 1-4. After I experienced storage problems in my own room, I designed and built a long counter with cabinet space beneath and book cases above. In the fall I ran a workshop for the teachers. During that workshop, I familiarized the teachers with the major aspects of the program, stressing the importance of teacher enthusiasm, preparation, organization, student evaluation, and student behavior. We worked through the beginning activities of **Kitchen Physics**, an **ESS** unit taught in 6th grade. We compared teaching strategies, goals, and science content of this activity to one suggested by David P. Butts in **Teaching Science in the Elementary School** in which students attempt to memorize a list of nonsense words. It was a successful session. Before the workshop, when the program was first discussed, teachers were not overly enthusiastic and two were quite negative. After the workshop, the units began and the teachers seemed to reflect the children's enthusiasm. Now, all the current teachers like the units they are using. They are now very supportive.

During my entire time at Porter-Gaud the school administration has provided both encouragement and support and has approved every budget request. For three years the 4th through 6th grades came under the high school department where I had as much cooperation and support from the science chairman as I had from my principal. The teachers have been very cooperative as well.

In the summer of 1980 I received a letter from the Board of Trustees of the school commending me for the science program and my work with children in the science clubs. Such recognition and support has really made a difference. In addition I have been permitted to have science clubs during my free or study hall periods. The administration has always permitted schedule changes when possible for field trips or guest speakers.

There is nothing unusual about our physical facilities. My 5th and 6th grade classroom is almost square, approximately 8.3 meters on each side. Our five laboratory tables are usually arranged in a rectangle but, when I have more than 24 students, I use two little tables to make a 6th work area. My desk, usually in the back of the room away from traffic, is rarely used. There is a bathroom, windows, and a walk-in closet. In this closet I keep all chemicals, the microscopes, insect and dip nets and miscellaneous large pieces of cardboard. On waist high cabinets by the door are a marine and a fresh water aquarium. There are three bulletin boards, one sitting on the chalkboard tray, one over the cabinet with aquaria, and a very large one over the long counter. I frequently have displays on these. In addition I always put pictures outside my door and in the bathroom. On the long counter there are usually aquaria with either a visiting lizard, snake or other animal, two dissecting microscopes, two balances, a hotplate, and, toward my end, the overflow from my desk. In front of the windows is a long counter composed of old dressers (four drawers each) which were nailed together. I use the drawers for storage and on top of these are usually plastic basins containing turtles as well as shoeboxes with supplies for the current 5th and 6th grade units.

In the other classrooms there is adequate storage space and most have good light for growing plants. All rooms, with the exception of two, have attached bathrooms and thus have a water supply quite close. With the exception of these two rooms the others are all identical in size to the 5th and 6th grade room.

Our equipment is ordinary as well and what we don't have we sometimes borrow. The Lower School owns five second-hand AO compound microscopes and two dissection microscopes. In addition we have "on loan" from a local college six very old but usable compound microscopes. We also have two movie projectors (one new, one very old), a slide projector, and several film strip projectors. I also have access to the high school telescope.

Our original start-up cost for grades 1-6 ws $1,600. In the primary division the cost per pupil last year was $1.50. In the elementary division the cost per pupil was between $2.50 and $3.50. Last year, due to the escalating cost of supplies, all materials for science clubs were not included in the budget. Instead a small fee ($1-$5) was instituted for each club to cover all supplies. Units are supplemented also by **Weekly Reader** assignments and outside speakers.

In the 5th and 6th grade room each table has a number and a "captain" for the week. Daily supplies are usually in shoeboxes at one side of the room and students are responsible for distribution, collection, and cleanup. Students always have access to the beehive, dissection microscopes, balances, field guides, and any equipment they may ask to use. In other classes materials are distributed in various fashions depending on the unit. Other teachers always have access to any equipment or supplies in my room.

At the beginning of the year I encourage students to bring in shoeboxes and babyfood jars and, throughout the year, I request newspaper. Whenever we have an especially messy day, captains get newspapers for their table before they get their shoebox. If a table is left wet or the floor is dirty, students have been told they will not have science the following day. In nine years I have never had to enforce this rule.

In our room we usually have a number of animals including two tortoises which roam the floor. Each table in my homeroom has responsibility for feeding these animals for a week. Students have other responsibilities as well; they take attendance, record daily outside temperature, write the date on the board, and do K-P in the lunchroom.

Students at Porter-Gaud are bright and very perceptive with IQ levels ranging from average to above average. Class size varies from year to year but, in the primary grades, there are usually between eighteen and twenty-two children per class. In the elementary grades the class size is usually closer to twenty-five. The high cost of tuition means most students come from affluent homes, although there are some from average homes and a few who have tuition loans. For the most part students are serious about school and realize that they are there to learn. All students seem to like science very much and are enthusiastic about the class exercises. Parents frequently tell me that they hear in the carpool or at the supper table about what their child has done that day.

Students usually work in small groups and must learn to cooperate. In grades five and six part of their science grade is based on this group harmony. Although Porter-Gaud does not have truly individualized instruction, opportunity for individualized science projects is offered through the different science clubs available to the 6th grade.

OUR PROGRAM

My goals in science education are:

* developing positive attitudes toward science
* instilling respect for the natural environment
* stimulating rational thinking
* encouraging students to consider some phase of science as a possible career choice.

These stated goals are very different from the implied goals I found when I arrived. When I first came to Porter-Gaud, science was another reading class and one of the least liked subjects. Now, it is the most popular at all grade levels.

Many of the students in the Lower School will go on to college and become the decision-making members of society. It is especially important that these students have an appreciation of nature and an understanding of interdependence and cause and effect relationships. Our science program stresses a respect for the natural environment as well as the future of man and his environment. Human adaptation is also central in our emphasis on problem identification and solving techniques. Through classroom discussion of topics such as acid rain, water pollution, radioactive dumping, land use, and the importance of wildlife areas and the marsh, science-related social issues become another focus.

Inquiry processes are emphasized as we explore all the basic areas of science: physical science (motion, astronomy, heat and cold, light, properties of liquids and gases); biology (food chains, life histories, the ear, the eye, embryology, the cell), and chemistry, as well as some mathematics (metric system, graphing). Students use the knowledge gained through inquiry to identify and solve problems and make decisions.

Through field trips to the Medical Complex, the College of Charleston's Marine Lab, the Charleston Museum, and many local natural areas I hope to encourage students to think about applications of science and science as a career. I especially try to encourage the girls. Every teacher at our school invites local professionals (many times parents) to come to the classroom and share their expertise.

Our entire program illustrates to the students that they can affect their environment. From the first grade, students develop responsibility by caring for plants and animals. In the 4th through 6th grades we dicuss ecology and the importance of clean air and clean water. In the communities unit we discuss the hypothetical problems of building a road through a farm. Films viewed during the year stress the need to solve the acid rain dilema and conserve our natural resources.

Our strategy involves modeling behavior as well. Whenever I take a group of students on a field trip, I always bring along a garbage bag for our trash and any we find along the trail for we try to leave an area cleaner than we found it.

By taking advantage of the Francis Marion National Forest students become aware it is there for everyone's use. Many students like it well enough that their families have returned for field trips of their own. Many topics come from these trips. When we talk about birds we discuss why songbirds are protected; we also discuss the declining reptile populations and why some clear-cutting practices damage the forest ecosystem. We dicuss how fortunate South Carolina is to have abundant acreages of **Spartina** and why even a little bit should not be destroyed. Students don't just discuss issues; they take action. Last year the Lower School had their first bake sale to raise money for local research on the Loggerhead Turtle. We raised $210 in one day.

I am constantly looking for new techniques to use in my classes or at other grade levels. I subscribe to **Science and Children,** I have a large library of paperacks which I re-read, and I attend meetings where I try to do a lot of talking with other teachers as well as attend sessions. I frequently am the recipient of useful articles from parents, local professionals, and my principal. Although I subscribe to **Science and Children,** the school does not. If there is an article a teacher would be interested in, I loan her the magazine. I get many ideas from professional journals. I find a hands-on science program to be the best and most challenging way to teach science. I try to present all topics in a challenging manner and treat children with respect. A material-oriented program reflects the nature of science and allows for much creativity as well.

I think one of the most interesting facets of teaching science in this manner is the fact that students become aware that data can be interpreted in different ways. This occurs from first grade through the sixth. Each new hypothesis sparks their curiosity and causes them to ask more questions and become more flexible in their thinking. When the students can test their ideas and see which interpretation is best, they have experienced what a scientist does. A good example of this occurs in the Kitchen Physics unit when students try to explain why the plain water column is shorter than the soapy water column. We test all ideas, as best we can, and finally come up with the fact that water forms a drop faster due to its greater cohesion.

When one reads about an experiment it sounds very easy, but when a person undertakes to try an experiment a true appreciation of the associated problems develops. All grade levels come to realize that science is hard work, especially when working with living creatures. Children's plants and animals die and they must try to look on with someone else. In third grade there are often problems with contamination during the unit on Mystery Powders. Due to complicated problems with the communities unit one year, I started having the students copy down Murphy's Laws. Now when someone's experiment goes askew, an astute student blames it on Murphy. The fact that resolving problems is not easy is reinforced by the material students read in the text. Edison tried lots of substances before he made a satisfactory light bulb. Fahrenheit searched the world to find the coldest substance. Biographical sketches support their first hand experiences.

The success of the program is dependent on teacher enthusiasm. The attitude of the teacher fosters a positive learning atmosphere. In addition it is also critical that the students enjoy what they are doing. Children love to manipulate "science equipment", even if it is a simple eyedropper. In addition there are some children (who may be doing poorly in other areas) who find they are able to excel in science. This excitement in the children has a corresponding effect on the teacher.

The science teacher must also be organized. Equipment and supplies must be kept up to date and in working order. Equipment must be ready when the children come to class and distributed and collected in an organized fashion. In addition the program needs the support of the administration, not only financially but also emotionally. It is reassuring to know that the administration regards science as a subject equal in importance to math and reading.

Most of our units are based on the Science curriculum Improvement Study (SCIS) and Elementary Science Study (ESS). We use a number of the units:

Curriculum Outline

Grade	Topics
1	Butterflies, Growing Seeds, Spinning Tables, Changes
2	Brine Shrimp, Life of Beans and Peas, Light and shadow, Match and Measure
3	Eggs and Tadpoles, Starting from Seeds, Mystery Powders, Primary Balancing
4	Batteries and Bulbs, Rocks and Charts,

	Where Is The Moon?, Clay Boats, the Solar System, Mountain Formation, Ecosystems
5	Mealworms, Ice Cubes, Heating and Cooling, Optics, Pendulums, Colored Solutions, Communities, Social Insects, The Eye, Amphibian Development, Birds, Turtles, Density
6	Kitchen Physics, Balloons and Gases, Daytime Astronomy, Small Things, Metric System, Astronomy, Basic Chemistry, Ecosystems

Students are not involved directly in the planning of the lessons, but, during the units, there is student input. No two years are ever alike. There is no set time to complete a unit and this flexibility allows students to pursue their own interests. At the end of the school year 5th and 6th grade students evaluate the units we cover. Most students say they liked a particular unit the most and another the least, but usually there are no units they dislike. Students also are very involved with classroom management as I am a person who likes to have things neat and in order. Mrs. Dillard and Mrs. Linder both suggested that students help with management. I was told not to expect the classroom to be neat as a pin. They were right; so, while I try to get things cleaned-up between units, during units my classroom may be quite disheveled. Through classroom management I try to give the students as much involvement in decision-making as possible.

In grades 4th through 6th two texts are used to supplement the **ESS and SCIS** units. They are **Elementary Science: Learning by Investigation**, 1973, Rand McNally; and **Modern Science**, 1972, Laidlaw. Usually a class will work with an **ESS** unit and toward the end of the unit read in the text. A few units which I have developed on embryology, turtles, birds, the eye, the metric system, astronomy, and basic chemistry are also followed by chapters in the texts.

If you visited for a short period of time you would observe students actively involved in experimental work, recording data in journals, taking part in class discussions, and possibly giving reports or taking tests. In the 5th grade this week we have been working with pendulums. For two days students explored the effects of changing string length, size, and mass of bob. We also read in a text about Galileo and making hypotheses. Then, students predicted the effect of string length, mass, and displacement on frequency of swing. We spent two days experimenting and gathering data. After discussing variables and constants, students graphed the results. Students also worked with salt pendulums and coupled pendulums and now will read about Aristotles' ideas. They will make their own hypotheses. I will demonstrate Galileo's experiment with an inclined plane and, for homework, students will calculate the speed of an object dropped off the Empire State Building or other tall structure.

This week in the 6th grade we have been working with Gases and Balloons. The students spent two days working with bromothymol-blue and vinegar, or ammonia and baking soda. Then, we discussed similarities and differences of these two sets of chemicals. In the process, I introduced the terms acid and base and gave them litmus paper to take home. The next day we listed all students' findings on the board and discussed why some substances might be listed under more than one heading. We briefly discussed the fizzing of citric acid and baking soda and then students proceeded to collect and test gas with bromothymol-blue and limewater.

After brief directions about collecting techniques, the students collected gas by displacement of water and did a flame test. They weighed their gases in balloons. We also saw a film, **Chemistry in Nature.** an excellent movie made in Japan. The film touches on acids, bases, indicators, and the chemical changes going on all around us. Students also read in their text about other indicators and the pH scale. Students also produced and tested the properties of hydrogen, oxygen, and "canned" helium. Students usually take a group or table practical exam where they test and identify a mystery gas. They will read further about chemical changes in a text, do a report on a gas, see a filmstrip on acid rain, and complete several more activities which are appropriate.

During the last few days you also would have observed me "drafting" students to assemble pendulum supports while others dismantled and cleaned terraria. I might be making up solutions of BTB, filling jars with various chemicals, setting up shoeboxes, listening to reports, helping collect insects, holding class discussions, and during experiment periods, walking around the room observing and asking questions.

Invited speakers visit the classrooms at least once a year. In the 5th and 6th grade we have had speakers on the eye, teeth, the skeletal system, birds, turtles, and the electron microscope.

Our unit on Light from **ESS** Optics and the Laidlaw chapter on Light takes a little over three weeks and is typical of our sequence.

Day 1	We set up six light boxes and students experiment with narrow and wide bands of light. They reflect beams of light with mirrors, hitting objects and people in room or try to send one beam around the light box. Usually there are four students to a box.
Day 2	Students set up two mirrors so a beam hits one, then the other, then a cardboard screen. They do this few times trying to hit a particular spot.
Day 3	They continue hitting spots and may use more mirrors.
Day 4	Using very large pieces of paper (from wide roll) students draw light plans and try to place mirrors in correct places so the beam will follow their pencil mark when lights are turned on.
Day 5	We work with 9 x 11 size paper and make more light plans. We have a discussion at the end of the period examining the "secret" of how light hits a mirror and is reflected at the same angle.
Day 6	Now the masks on the light box have three colors. Students investigate mixing colors--using a probe to cast colored shadows. At end of period we talk about light mixing.
Day 7	Using crayons, students draw pictures with certain colors so that the picture looks one way in one light and another way in another light. They learn that red crayon does not show up in red light.
Day 8	Changing back to narrow slit masks, students

are first given a container of water and then a comb. They are warned about the effect of water on electrical outlets and extremely hot 200 watt bulbs. They are also told they must not misuse their scientific equipment (i.e., use comb in their hair). They observe diffraction and dispersion of the spectrum. Briefly we talk about rainbows and spectrum.

Day 9 Students use the containers and observe the effect of adding salt to the water. They also observe the effect of using a wide container and a narrow container. Usually someone will ask what happens if there is no water in the container. We also have a square container which we try with very interesting results.

Day 10 This is the hardest of all the days. Students need to find out if red light is bent in a different way than blue light. They are given paper and rulers and the light boxes and paper are taped to ground. Usually, after some experimentation they can detect a slight difference--the blue light bends closer to the box. I ask where they think green comes--usually after experimentation some students can see it is between red and blue.

Still sitting on the floor I turn on room lights and we discuss findings. I ask them if they have ever heard of Roy G. Biv--usually after much discussion someone realizes it stands for the colors of the spectrum!

Day 11 This is a sad day for students as we are back to conventinal classroom and they read in Laidlaw a chapter on light and I pass out a worksheet to be filled in.

Day 12,13 We discuss the worksheet. Since all the answers are not in the book, we have lively discussions.

Day 14 We see a movie on light, talk about ellipses, Doppler effect, and other light phenomena.

Day 15 We see a filmstrip on light and lenses.

Day 16 Written test on light as they have experienced it.

Day 17 We go over the test and write corrections in journals. Then students get their test back.

Day 18 This unit is followed by a unit on the eye--this is one time that they must read the chapter first. We look at plastic models and they do a group dissection of a bull's eye. We have a speaker on the eye and they look in another student's eye with an ophthalmascope. Then, we proceed to a unit on the camera and how an eye and a camera are similiar. Students take pictures; develop negatives; and make sun print positives. The unit is concluded with a photography contest with prizes awarded for best composition, action shot and trick shot.

I think what may make the sequence of science instruction unique at our school is that when students arrive at 5th grade, I am completely familiar with what they have covered. During the 5th and 6th grade I constantly refer back, reinforcing and building on previous concepts. For example, when the 5th graders are observing the development of salamander larvae, we discuss what they remember about the frog larvae they studied in 3rd grade. Each primary grade studies an organism's life cycle. We review this in the 5th grade with the mealworm and the honey bee. I tell them many times in the 5th grade that they will be responsible in the 6th grade for all we cover. I try to impress on them the importance of learning for a lifetime rather than just for the next test. In addition I try to make the students realize that if they enjoy science and want to be a scientist they need to be good not only in science, but in math, history, English, composition, spelling and possibly art as well.

While in the primary area scheduling is left to the discretion of the individual teacher and science may not be taught every day or even every week, at the elementary level students have a 40 minute science period each day. The fifth grade student also has an additional 40 minutes per week for 12 weeks in science club. Sixth grade students have an additional 40 minute period per week in science club for 24 or 36 weeks.

Science Club is an integral part of the 5th and 6th grade curriculum. Almost every student in the 5th grade is a member for one term. In the 6th grade membership is limited to two terms and students select the topic they wish to study.

In science club we do many more activities:

5th grade - Tangrams, simple calculators, Mystery Powders, nature walks, insects (fall), paper airplanes (winter), Wildflowers (spring).
6th grade - Insects, Birds, Flowers, Marine Life, Earthworms, Pinhole cameras, Chromotography, Skeletal Preparation, Crystals.

In the 5th grade there are usually about 15 members per term with the activities repeated each term. In the fall are students introduced to insect collecting. In the winter, we construct and fly paper airplanes. In the spring we collect and identify the many wildflowers around the school.

In the 6th grade each student signs up by topics, and most are able to be in two clubs. Occasionally if space permits a student may be in as many as five. In Marine Life students visit our local beaches (at least twice), collect and identify organisms, write a special report and visit a marine laboratory. In crystals each student grows an alum crystal (and others if time permits) and writes a report. During insect study students learn how to collect, to pin, and to classify insects. We visit several types of habitats. During chromotography students work with colored ink, chlorophyll extracts, simple amino acids, and then visit the Toxicology Lab at the Medical University. Students in Skeletal Preparation use the frogs from the 5th grade Communities unit and prepare a wet mount preparation stained with alizarin red and stored in glycerin. In Earthworms students collect worms in the school yard and observe their anatomy and behavior. They dissect preserved specimens as well. In Birdlife students keep a weekly record of birds observed at school and on our two weekend field trips. In addition, last year I took the group to visit the aviary at the Riverbanks Zoo in Columbia. In Pinhole cameras, each student builds a camera and many are successful in taking pictures with them.

This year we have two new clubs. In rocketry each student will build an alpha roket and shoot it off at school. We hope to be able to measure their altitude. Since so many 5th graders enjoyed the wildflower part of the science club, we have started a 6th grade club and I have gotten a plant press.

We think we are successful because, after leaving the lower school and taking the required physical science and biology in 9th and 10th grade; 62% of juniors are taking chemistry, 11% are taking geology, and 44% of seniors are taking physics. This year 24% of the seniors are taking advanced biology as well. This success is dependent on teacher enthusiasm since the attitude of the teacher fosters a positive learning atmosphere. The teacher must be organized and equipment and supplies kept up to date and in working order. When science periods are restricted by a time limit, equipment must be ready when the children come to class and distributed and collected in an organized fashion. The teacher needs to act less like a repository of information and more like a resource person who points the students in the right direction so students can ask and answer their own questions.

The teacher needs to have patience and realize that with this type of teaching the room is sometimes noisy. The teacher needs to talk less in class, give students time to answer questions, realize there is usually not one right answer to a question, and treat the students with respect. When things go wrong, the teacher should try and make a positive learning experience out of it.

EVALUATION

In the first and second grade, students are not formally evaluated. Teachers merely observe each child's reasoning and developmental skills as they progress through a unit. Student participation and interest are observed and used to determine the strengths and weaknesses of the various units as well as the effectivenes of the teacher. In the 5th and 6th grade a written evaluation of the year is done by each student. I also rely on comments and letters from the parents. But mostly I try and judge the effectiveness of a unit by how students do on the inferential questions I ask on major tests. They usually do very well. Recently I was told by a high school teacher that he had been impressed with what the students in 10th grade remembered from the 5th and 6th grade.

Formal evaluation based on journal entries and classroom participation begins in third grade. In the fourth grade, evaluation includes written and oral work, including reports, projects and tests.

In the fifth and sixth grade the report card grade is determined by averaging journal grades, test grades, and a classroom grade. Completeness of journal entries is valued above neatness. A short monthly book report is required and this grade is averaged with the test grades. Tests are composed of open-ended and inferential type questions as well as some recall. The classroom grade reflects the student's cooperation with his group, his attitude, and his skill with science equipment. An examination with essay and multiple choice questions is given at the end of Term I and Term III. While my basic goals for science and children have not changed I am always looking for better ways of meeting them as I try to make my program reflect the nature of science and how children learn.

In the spring the 6th grade takes the Stanford Achievement Test. Grades for the entire class were 9.3, 9.4, and 9.3 in 1980, 1981, and 1982 respectively. While our students, do well, I do not have much concrete evidence of achievement of students other than reports and research pursued in class and science clubs. After attending the National Science Teachers

Association Annual meeting in Washington a few years ago, I attempted to write pre-and post-unit tests as suggested by Dr. David P. Butts. I'm afraid I never really followed through. Somehow, allowing students to be tested on material they were about to learn sort of let the cat out of the bag and took away much of the fun of the **ESS** unit. Last year I had a JETS club in addition to our usual science club. Students entered local competition and one of my students won the toothpick bridge competition. Because I felt over-extended I am not sponsoring JETS this year.

I WISH

Children will always be curious. They enjoy manipulating equipment, they are fascinated by animals, and they like to try and solve puzzles. I wish I could find a textbook that has up-to-date, in depth coverage of the topics we study. Most seem to jump from subject to subject and do not have much content. But, even if I found one, it would be for SUPPLEMENTAL use only! I also wish we did not have to give exams as I feel these are a waste of classtime at the fifth and sixth grade level.

I wish the school could have the use of our own planetarium. It would be helpful from grade one through high school. I try to have three observation nights during the winter, but counting on the weatherman is tricky.

I wish we had more time. I think the optimal class period is closer to 50 minutes per day, but scheduling is not an easy task. We should be buying one microscope each year to prepare for the time our microscopes "on loan" are recalled. It would also be nice to purchase some films instead of relying on the state department film library.

I would like to see the primary grades teaching more science by adopting **SCIS** units for grades one through four. Recent articles in **Science and Children**, especially "How Effective Were the Hands on Science Programs of Yesterday", by Shymansky et al in **Science and Children** (November/December 1982) lead me to believe **SCIS** may be superior to the **ESS** units in raising achievement levels and increasing creativity although **ESS** seems to be better liked by students. However, the primary teachers may like the format of the **SCIS** better since there is more information as to what the teacher is to do and say.

With that in mind, if I wanted to implement this program in another school, I would have workshops to show the teachers what an **ESS** unit is like and invite them to visit the classrooms of our school. I would tell them that there is no perfect program which is ideal in every situation. They need to investigate several programs and adopt those things which will work for them.

I wish college students, whether planning careers in elementary or middle or high school, would take more science courses. Every person in today's world needs to have a science background. Ideally it would be nice if a new teacher had considerable science experience. However I feel it is more important that the person like children, enjoy learning, be organized, be flexible, and not be afraid to experiment with new techniques.

If I wanted the program to fail I would reduce the time per week which is set aside for science, use texts as a core rather than a supplement, and do away with science clubs. For me, the reward of "touching the future" through children is a motivating force which drives me to see our science program evolve as far as it can.

Chapter 10: Elementary Science Program

By

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Unified School District #373, located in central Kansas on the open prairie, is in a town of approximately 17,500, 20 miles north of Wichita. The school enrollment is 3,200, operating on a K-4-4-4 plan of organization. The elementary science program is operational with 80 teachers and 1500 students in grades kindergarten through six. Grades K-4 are in regular self-contained classrooms while fifth and sixth grades are in science labs with tables and stools and science equipment.

Average class size is 20 students, our handicapped children have special ed rooms in several elementary schools, the socioeconomic status is average to above average, and the attitude toward science is most positive. The program, in existence for twelve years, has evolved and been refined based on our growing perception of inquiry processes, problem-solving, hands-on learning styles, and the needs of students and teachers using inquiry. Program structure allows for great individuality and diversity of content and learning style within the format of a unifying inquiry and problem solving oriented structure.

Twelve years ago we had a district-wide textbook-centered program with no supplies. In our old program students took turns reading the book, having discussions, and answering questions. The students found this rather boring unless the teacher was especially interested in science and spent time and money bringing additional supplies and activities to the classroom. As a result, we had some outstanding and many poor science classes.

While doing a year's study at Michigan State University through their Experienced Teacher Fellowship Program, Glenn Berkheimer encouraged me to analyze our program and develop a ten year plan of action for change. Glenn also provided an initial study of current science programs and information on personality factors needed to be a facilitator of change.

I gained much inspiration at annual meetings of the **National Science Teachers Association** and studied elementary science programs at Marshalltown, Iowa and Jefferson County, Colorado. (For more information on Jefferson County, see chapter 4 in this **Focus on Excellence Monograph** as well as chapters in the science/technology/society monograph and a special 1983 publication describing Jeffco as a district, **Portrayals of Excellence.)** Twyla Sherman, Wichita State University, gave me support during the change within the district and David Butts, University of Georgia, provided a problem solving model.

From beginning stages to now, **NSTA** conventions have been one of the major sources for finding answers to our problems. In an **NSTA Sunoco**

Seminar on ecology, I heard discussed the principle "The greater the diversity, the greater the stability". This became the accepted principle on which our curriculum content was developed. At a crucial testing point of the program, it was the only thing which saved it.

Now, each grade level has a unique Science Guide as well as published teacher manuals to help teachers choose learning activities. The teachers also have in-service experience doing activities themselves which they can take back to their class. The activities are very much hands-on, focused initially by a teacher's divergent questioning. Later, as the lesson progresses, the focus turns to student questions in continuing lessons within a unit. Student questions are highly valued and often are written large and hung in the room for all to see and think about.

Effective focusing of student behavior in our program causes children's minds to "come alive". We value a dynamic interchange between children's ideas, questions, and environment. Children learn to observe; openly question; and respond honestly as they infer, perceive, make decisions, create experimental designs, make tests and question results. It has been a privilege for me to teach students, observing the higher degree of reasoning and thinking skills demonstrated by the students in our program.

Along with science we have a very fine hands-on, activity-oriented health program emphasizing classical problem identification and resolution. We have identified basic health laws in movement, nutrition, cleanliness, recuperation, and mental health. This aspect of the program emphasizes each unique student working out his own personal health program around these laws.

In our Prairie Outdoor Classroom, one of the emphases is valuing natural history with the goal that as the young people approach decision-making roles in the community they will feel a sense of custodianship. Our classroom work on the prairie is interdisciplinary with **SCIS** Science Concepts used as a broad base.

Often variation in interpretation of data is the focus for an investigation, especially in the intermediate grades. Observing variation in interpretation of data creates interest and sparks the design of an experiment. The teachers are trained in workshops to use this approach. In early grades, data interpretation and variation is a matter of observation and verbal inference on the cause of variation. In our program the children enjoy this approach.

Since our entire program is built on the model of resolving problems we find that we cover less content because of the great amount of time it takes to create ways to test and resolve problems. Our students experience this many times each year. In second grade our science builds on concepts relating to weather. Third grade is built around all the life activities taking place in a guppy tank filled with snails and three kinds of plants while in fourth grade through sixth all units lend themselves to resolving problems.

The academic content of the program is found in the fields of life, earth, and physical science derived from a fusion of **SAPA** processes with **SCIS** concepts and supplements from **ESS** units in addition to units we've written to give us a broader base. Most of the units we wrote have been in the areas of Health & Nuturition, Weather, and units relating to the Prairie.

Teacher are encouraged to include outside people who are involved in scientific careers or hobbies. We have a local college with such resource people available to us. An outstanding researcher, who often helps us, has been working with prairie snakes for over 20 years and is the authority in this field. Through current events and library research students also identify people in scientific endeavors.

OUR BEGINNINGS

While at Michigan State University on an Experienced Teacher Fellowship in 1968-69 I was assigned to evaluate my local Science program and make a ten year plan of action. I came home, implemented **ESS** units in my own class, brought in two neighboring classes, and received $500 to develop one elementary school Pilot Project. This pilot involved the 9 teachers in my school and a year later I presented a ten-year proposal to the superintendent. He then asked me to present a district wide proposal to the school board. Major tenents of the proposal were to:

1. Select and implement inquiry process science in grades 4,5, and 6
2. Provide inservice training for teachers with each new unit,
3. Hire a half-time elementary science consultant
4. Make supplies easily available to teachers for a hands-on science curriculum.

The district-wide proposal was granted and the program began. It now has expanded and developed from this point according to the perceptions and needs of students and teachers.

In development I was given everything that was requested including funds as well as training time off for teachers during the school day. There was easy access to the superintendent's office when problems arose and letters of communication were sent from the superintendent when teachers were performing outstandingly with the program. Today, the administration has completely changed staff; yet, while other programs have been financially cut back, ours has not. I and the science program have full administrative support.

The second year of the program, after the pilot, we began to involve the teachers in decision making as well as in-service training. Today, the program carries a $5,000 supply budget, $600 transportation budget, and a $1,900 in-service budget per year. Cost per pupil is $17.30. I work half-time as coordinator and teach seventh grade science the other half. There is a half-time secretary-aide for the program as well. I believe the factors which contribute to the success of our program are having:

* **Leaders** who understand inquiry processes and people, who listen and learn how to help teachers become aware of the model.

* **Regular** (built into the school day) in-service training sessions which help teachers to be aware of ways to develop inquiry, process oriented, and hands-on Science lessons.

- **A model** that allows for diversity of units taught, yet unifies the program.

- **Teachers willing to risk new ideas and teaching strategies.**

- **Models** for focusing questions and providing reasoning, thinking and processing of experiences.

- **Adequate** supplies.

Basic classroom management systems are taught in in-service workshops and I perform any needed task to keep the system operating smoothly. In addition to regular units, the Science Coordinator's office manages a check-out of 250 individualized, hands-on system units which are in constant use. Also, the organization and management of outdoor classroom time takes place in the Science Office.

OUR PROGRAM

Our essential content is not traditional. We emphasize the observation of the characteristics of living and non-living things and the notion of change. We want students to understand that everything is in the process of becoming different. We observe the interactions of living and non-living things. We define a group of objects interacting for a purpose as a system and observe many systems both living and non-living. Students study living things as organisms; their life cycles grouped as populations interacting together as communities. We strive for awareness of basic laws for keeping our bodies functioning healthily in nutrition, movement, sanitation and recuperation. In the process, we teach the skills of observing, classifying, predicting, questioning, measuring, record keeping, variables, designing experiments, and comparing and evaluating results with predictions. Some activities focus on energy sources, transfer, chains and change.

I feel the outstanding characteristic of our program is the in-service training which takes place during a school day. With a substitute put into the classroom the teachers gather to learn the creation of process skill lessons, questioning strategies, classroom management, grading techniques, and unit orientation by hands-on role playing. Our greatest emphasis is in Questioning Techniques. We emphasize changing narrow lesson objectives into divergent questions and we have a question summary model that allows honest response from the student, helps students to synthesize the happenings of the lesson, and helps the teacher evaluate how successful was her instruction.

Another outstanding characteristic of our program is the Prairie Outdoor Classroom. The city of Newton gave us, for natural history study, 160 acres of Sand Hills Grassland. Our classroom work on the prairie is interdisciplinary with **SCIS** science concepts used as our broad base. A teacher may choose from an outdoor manual or other material the kinds of activities the class will do while on the prairie.

The prairie may be used seasonly by the class or only yearly. Much classroom preparation is made before the trip with follow-through activities taking place after the trip. The teachers are given training for using the prairie as with any classroom inservice.

We are also very proud of our Health Curriculum which is unique in that it teaches principles one can use to keep the body and mind healthy and help individuals to be healthier. It emphasizes the uniqueness of each person within the framework of sameness of function. Health is presented to the students in a hands-on, activity oriented approach. Our guides were written by our teachers under the guidance of the Science Coordinator. They do not talk of disease but of greater levels of wellness and well-being.

Our program makes science and other subjects come alive. A dynamic interchange between objects, children's ideas, and teachers's ideas, it allows for student choices and decisions, testing, and processing whatever happens, and beginning the cycle again with questions which arise here. The teacher's major role is as a catalyst or facilitator helping first-hand experience to come into focus as defineable problems through good questioning and identifying inferences. Students are actively involved in each step of problem identification and solving and in choosing the focus, designing the experiment, gathering data, and processing the information gathered. A teacher who learns to function this way also uses it in other discipline areas because it brings students, teachers, and subject matter alive. It allows, with time, a teacher to free herself from texts and to feel confident to take the interests of the children and the objects at hand to create a highly motivational, reflective learning experience. This is done through the use of a questioning model which encourages children with hands-on to explore, observe, communicate properties, infer, design experiments, collect data, and process the results. Teachers are models of questioning; a divergent focus. They model the processing of experience through redirecting questions, seeking clarification (rather than clarifying), and accepting all responses. Teachers don't ask leading questions; they ask questions which require students to think and "make up" answers. We don't ask questions requiring memorized answers. After asking a question, our teachers wait for a response. After a response, they listen actively. Much of a teacher's time is spend observing. We want to encourage childrens' ideas and questions of exploration. In doing this we also suggest new equipment to fit children's creative exploration and extend activities according to children's ideas. All the while the teacher is trying to get students to focus on the problem. She is expanding on responses from students and moving physically around from group to group.

This program correlates well with our overall institutional objectives. It brings added emphasis to developing the mind in both inductive and deductive reasoning skills. It adds strength to self-dependance, preparation for careers, add entrance into trade schools or colleges. It benefits all students from those lowest in intellectual capacity to those highest. It develops skills needed in problem solving wherever one meets a problem. Since this program offers a way to motivate and stimulate students to great effort in any area, it plays an important role in fulfilling the aspirations of the faculty who work with our children. An unintended consequence of this program is a greater amount of confidence, creativity and interest in science in the teachers who use it.

The characteristics of the program which most contribute to its success are the use of the unifying problem solving model with processes and questioning techniques around a wide diversity of topics. Teachers even have one period of "choice" for what they teach within the framework of the model. Other characteristics that contribute to its success are a Science Coordinator and regular in-service training sessions for teachers at various levels of teacher awareness.

In-service training during the first year consists of one 4-hour workshop per unit dealing with orientation, manipulation of materials, and classroom management. In the second year we provide a four hour workshop on questioning strategies. The third year teachers attend a four hour workshop dealing with inquiry strategies. Teachers also are made aware of classroom management systems in training; then teachers develop their own management systems. It is suggested that the teacher use this system regularly to save time and their own nervous systems.

Teacher attitudes and behaviors have changed considerably. Now, they involve children with materials through questions and are listening to a greater degree to students, talking less, questioning more effectively, acquiring materials needed, and moving among the children rather than always being in front of the class. Teachers now interact with small groups and wait for questions. They can say, "I don't know, what can we do to find out?" They carefully accept all responses, plan their discussions, and encourage children to design and try their own ideas to find out. All these inquiry behaviors encourage children's ideas, questions, explorations, and learning.

I asked one of our teachers, without premeditated thought, to tell me what our science program has done for her. She said, "It provides guidelines to get in where the children are thinking and to think with them; you can have an objective and develop a hands-on observational approach to help children internalize at a deeper level of learning than before. But, it takes time." For those who feel comfortable with the program, enthusiasm is much greater; and there is a willingness to risk learning and growing with the children.

Material requests are sent by teachers each May to the Science Coordinator's office. In the fall these supplies are sent to the teacher who ordered them. Each school has a storage area for science supplies. In addition, there is a central supply area where basics are stored and can be requested at any time. Students are changing as well and we feel they are making progress toward our goals:

> **Develop attitudes which enhance** problem identification and solving and to have the student apply these. Such attitudes are: curiosity, open-mindedness, intellectual honesty, doubt or a degree of skepticism of too quick authoritarian explanations, belief that phenomena are subject to investigation, freedom from bias, looking for cause and effect relationships, and accuracy. Simply, to be enthusiastic about science learning.
>
> **Develop skills of inquiry and critical** thinking and to have students apply these skills in any context. Simply, to have confidence in solving problems in everyday life.
>
> **Develop meaningful concepts and an** ability to relate these to other concepts to form conceptual schemes. Concepts are "ideas descriptive of classes of objects or events such as 'tree' or 'motion', and conceptual schemes defined as generalizations which show interrelationships between many concepts."

As the children plan together and work together, they are learning to adapt.

Any day you visited, students would be learning from working with things and with their fellow students. Students would actively be involved in observing some phenomenon, communicating with peers and infering causes or effects, designing tests to see if they were right, discussing their ideas, and questioning. All would be accomplished with hands-on objects. They would be enthusiastic, and it would be obvious their minds were very "turned on" and loving science.

Our approach to science lends itself to any and all subject areas. Therefore, being multidisciplinary, it helps in social studies to resolve social problems and issues. For instance, We have a unit related to change which deals with alternative futures in third grade.

Inquiry processes unique to specific disciplines are a strength in our program. The teachers are made aware of processes and trained to question so that Inquirv processes are developed within children's minds as they work with objects in their hands. In doing so children are constantly placed into decision-making situations relative to the science lessons that are taking place and within the social structure of the room. The teacher lends to this whatever scientific knowledge or resources are available. We have a career awareness program and director that the teacher calls upon to bring "hands on" experiences to her room.

Children of all grade levels are taught to make comparisons and judgements and to feel it's all right to "see it" differently than others, even your teacher. They are also taught that there are no wrong answers when dealing with observations and analysis. Thus, our problem-centered approach is flexible to the childrens' perceptions and inspirations as well as teacher guidance. This causes the program to be dynamic. A teacher is trained to change plans if children focus with interest on an aspect of the problem not thought of by the teacher. In essence, our program is child centered first. That means, we listen to them, encourage them to reason and relate to each other and to the world of people and nature around them. As a result, our teachers' commitment to human welfare and progress is communicated to the children through basic attitudes and activities.

We relate our lessons to the child's environment, home, what's happening in nature on the way to school, T.V., and other relevant aspects of the child's life. Or, with our format of inquiry problem-solving as we define it, we go to our outdoor classroom, ten miles from the city, for lessons. We also involve a historic one-room school, a pioneer's home, a college museum, the hospital, the central kitchen for school lunches, planetariums, and a health museum for study. Each grade level focuses on a unit in health which is certainly relevant.

Children work in groups of two on a regular basis; and, at times, in groups of four with adequate equipment for each. Since our program focuses on a problem, then each small group picks up on this and takes it in their own direction as their minds perceive it. So, by the end of the period, we will have as many problems or directions being taken as we have groups.

Much of our methodology is based upon current reports from NSTA, Piaget, Gagne, and Bruner and educational research in general. We have a rationale for teaching science--a rationale based on research about how children learn, the nature of science, and the effects of teachers on students.

The teaching strategies, questioning strategies, and problem solving model once mastered by a teacher are so effective that teachers automatically transfer these approaches to all aspects of the curriculum. I have watched this happen for ten years. It takes, on the average, three years to master this.

As a result of our strategies and content students rank Science as their most loved subject in elementary school. The community also responds most positively to this program. While funds and personnel in other disciplines are being cut back in our system, this program remains intact, recognition of its value to the development of flexibility and confidence in children's minds.

Students notice as well. A student, recently returned from obtaining his doctorate in Texas, stopped by to say the greatest asset in his higher education was his ability to concentrate and make decisions; attributes he attributed to our science program. In doing this we use a variety of commercial and locally developed units.

SCIS II units we use are:

Material Objects, Interactions & Systems, Subsystems & Variables, Energy Sources, Organisms, Communities, Life Cycles.

ESS units we use are:

Sink or Float, Mystery Powders, Batteries & Bulbs, Rocks & Charts, Tadpoles, Pond water, Butterflies, Life Cycle of Beans & Peas, Mealworms, Bones, Tracks, Ice Cubes.

Our Goal is to provide a balance of the life and physical sciences. We also have other source books such as: **Blood & Guts** Little, Brown, & Co., 1976; **100 Ways to Enhance Self-Concept in the Classroom**, Prentice-Hall, 1976; **Early Childhood Curriculum**, American Science & Engineering, 1973; **Beginnings**, Rand McNally & Co. 1974; **Rays of Dawn**, Concept Therapy Institute, 1950; **Trees**, Holt, Rinehart & Winston of Canada, 1977; **Teaching Science With Everyday Things**, McGraw-Hill, 1968; **Ten Minute Field Trips**, J.G. Ferguson, 1973.

Guides we have developed include: Properties of Weather - Grade 2, 1980; Rain Forest Systems - Grade 4, 1975; Experimenting with Plants - Grade 5, 1976; Leaves & Trees - Grade 5 -1974; Health - Grades 1-6, 1980; Prairie Resources Guide, 1979; Sand Prairie Animals - U.S. D. #373, 1979, by Betty Holderread and Jan Saab 1982; Energy & Conservation Activities for the Classroom, Energy & Man's Environment, 1975; **OBIS**, Backyard, Schoolyard, Pavement & Parks, 1979; **Using the Environment - Investigation**, Macdonald Education, 1974.

We work hard for science to get its fair share of time since great emphasis is placed on reading and math here. A teacher's mind is always busy with reading and math. The time per week scheduled for our science programs averages 112 minutes. We ask for 45 minutes every other day - or an equivalent of this in blocks of time daily for awhile - then laid aside for some other discipline.

EVALUATION

In the classroom we evaluate our program by children's responses to three major objectives. **Our first objective, stimulating an enthusiastic curious attitude,** is easily evaluated by the way students respond to our science program. Students now rank science as their most loved subject in elementary school. For a teacher to say "It's science time" brings a clapping of hands, bouncing up and down in seats, happy smiles, and positive verbal responses.

Our second objective, using inquiry and process skills, is evaluated by giving another activity with new objects or phenomena and asking the students to use designated skills. We have a model for teachers to use, if they choose, in doing this. **Our third objective, gaining and using meaningful concepts,** is evaluated with traditional instruments but with nontraditional results. In comparing our overall program with sister institutions we see that our high school students' ACT test scores have been higher than Kansas' average and also higher than the national average consistantly for the past ten years. We also have a higher percentage of students enrolling in high school elective science courses than our sister institutions.

Each teacher is allowed to devise her own standard for evaluating a child's personal grade. We have models for testing process skills and attitudes which the teacher may use if desired. We emphasize evaluating a concept or skill by providing different objects in a similar activity to test the child's performance. Teachers evaluate the program as well. If she is not enthusiastic about some unit, she may request one of the optional units for her grade level.

The principal is the curriculum leader in his building as well as a supporter of teachers' needs. Administrators are our leaders. They give us the broad framework of policy in which we are to develop our professional expertize. They coordinate our program with all other programs in the system.

Our program is still evolving according to trends and emphasis of the times. Teachers perceive needs and "sell" us on their ideas. Changes also are being made constantly as teachers and students create new activities. If time permitted, a maintenance system for disseminating more of these ideas to all teachers would help the program.

I would like the program to change, keeping abreast of current thinking and emphasis in science as established by **NSTA**. I would like it to change, reflecting the teacher's perceptions of the latest learning of topics in their studies and relecting current notions of psychology of learning. I would like it to change, reflecting the interests of the local community. More emphasis should be placed on the students themselves as a focus of study. I would like to see a greater perception of the dynamics of the problem-solving model by the teachers and a greater use of social issues in problem-solving used.

As in the past, changes will probably come from three sources. Teachers will perceive a need for certain topics to be added or deleted, administrators and the community will perceive a need for certain topic development, and I may perceive national science trends in which we need to be involved.

Our program will probably remain constant in its inquiry format which allows for changes in subject matter with a stability of approach. Consequences of change would be a good solid, stable science program relevant to the times, teaching boys and girls to inquire and problem solve at their level of capabilities. As a result, students would be interested, and teachers confident, excited, and involved.

If I wanted to start this elementary science program in another school I would identify teachers who wanted help in science. We would start with everyday kinds of objects easily available to teachers and kids and, with my simplest version of problem-solving (which originated with David Butts), we would have a one day training session. We would then follow through in six weeks with a half-day session, this one in tune with the problems teachers were having. We would also focus on questioning strategies. I have begun this process with the Salina, KS., school district which is three times bigger than ours.

Teachers in our program need questioning strategies, and skills of management, construction, and organization of lessons whose goals are identifying and using process skills and concepts, and developing certain attitudes. Teachers also need skills in group dynamics; the ability to listen for the purpose of perceiving where the child is related to program goals. Attitudes are critical. Without a love of kids and a willingness to adapt to needs and demands of the moment we cannot succeed. Success involves children in planning and having a plan of action worked out. Our teachers must respect kid's opinions. Knowledge is important as well. First and foremost, it's OK to learn with the kids; if you don't know, just say so. Using methods of teaching inquiry through hands-on-everyday things science is what fuels our science program.

Teacher Education workshops are one of three keys to our success. They still are a stimulus and catalyst for our program, providing positive input and a clearing house for problems. They will continue to have the same function in the future. Teachers in our program are rewarded by the joy of seeing children alive and enthusiastic about learning and having a chance to be dynamic and learn with the children.

Chapter 11: Schaumburg Township Program

by

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This k-8 school district serves Schaumburg Township in the Suburbs of Chicago, northwest of O'Hare Airport. The children, from kindergarten to eighth grade, live in six middle-class villages in the township. Although the Schaumburg Township School District has seen phenomenal growth since World War II, recently there has been a slight decline in enrollment. But, the communities served by the school district are positive about education and have generally supported innovative curricula.

The 800 teachers and 16,000 students work and learn in buildings ranging in age from post World War II to modern. The last of the 27 schools was completed two years ago. The smallest elementary building houses 300 students while the largest has 830 and the five junior high schools range in size from 650 to 1,050. Many buildings have been improved. In 1974, an observatory was built on the roof of a new junior high school. In 1975, a two-classroom Nature Center was built on the district's thirteen acre outdoor education site. Both of these projects were supported in a bond referendum and continue to be supported by the parents and general public in Schaumburg Township. Both installations are an integral part of the K-8 curriculum with the observatory being used by 3rd, 6th and 7th grade students.

Our classrooms are ordinary but adequate; all have sinks and vary in regards to size, shape, storage space and special facilities. The junior high school labs are well equipped and allow for a variety of experimentation. Our Physical Facilities also include a District Science Center, a centralized storage and refurbishing center. New units are moved from the center to individual teachers every nine weeks on a definite schedule. Each grade level from K-6 completes three science and one health unit each year. Every teacher receives a complete unit except for audio visual materials which are housed in school Learning Centers or at the District Media Center. Also provided in each kit is a material package for 30 students and activity sheets for each student. Although Junior high schools have science storage areas housing materials used by these grade levels, quantity buying necessitates District storage of some items. Any materials needed for a recommended activity within the guide are readily available so that teachers do not have to provide them on their own.

Materials are **ESS** or **ISCS** based with a wealth of locally and commercially developed enrichment materials to augment the program. Our complete curriculum includes filmstrips, distict written newspapers, activity sheets, learning station booklets and revised teacher's guides. Computers are new to the program and a few programs specific to the curriculum have been developed. Noteworthy computer programs have been developed for the 5th grade Rocks and Charts unit and the 6th grade Astronomy unit. Filmstrips such as "Water Filtration" and teacher education video tapes of heart dissection also have been developed for the curriculum.

Prior to the district-designed program, a textbook approach with little or no "hands-on" activity was used. The content within the textbook and suggested teaching procedures formed the guidelines for what was to be taught as well as how it was to be taught. Recent developments in science teaching methodology made it evident that learning models were needed that would provide children with activities allowing interaction with the environment. Time to do this exploration, critical to such an approach, was also necessary.

Our new program has been developed through local support with Federal or special state funds being used only in areas of enrichment. On-going functions of program implementation and maintenance are incurred through district budget.

OUR PROGRAM

Hiring a fill time Science Coordinator provided an initial impetus for our program. Selection of appropriate available science materials and the approval of a centralized materials center by the science/health teachers committee, the administration, and the Board of Education led to efficient and successful implementation. While our basic process-oriented curriculum would be adequate, bond referendum and voter approval of a Nature Center building on a district-owned 14 acre site with a full time Naturalist allows us to provide a truly outstanding elementary science program. Board approval of an observatory and funds to hire personnel to conduct evening classes correlated with 3rd and 6th grades astronomy units were further evidence that our district wanted an exemplary science program.

Our committee developed a basic philosophy for the science/health curriculum stating that process and inquiry learning permeates the total development and implementation of the curriculum and teaching methodology. The philosophy has been consistant throughout the initiation, implementation, revision and modification of the curriculum. The district philosophy includes objectives for logical thinking and creative skills. The science program complements this area of learning by providing students opportunities to identify and solve problems and otherwise inquire. In examining each curricular area in the district's program of study, a strong tendency toward the development of self-awareness, initiative, creativity and process and thinking skills are evident. These skills are approached differently in each area but the end goals remain the same. Science instruction has emphasized these as major goals on a consistant basis. Generally, hands-on activities comprise 70 to 80% of science time. Class activities comparing data and discussing experimental findings comprise the remainder of the class period.

The curriculum is developed around the phenomenon of science as it interests children with science acting as a catalyst for the initiation of questions, inquiry, and further exploration. The program began thirteen years ago with the adoption of the **Elementary Science Study (ESS)** in 4th, 5th and 6th grades. Since that initial adoption, a full K-8 program has been developed using ESS in K-6, while ISCS and SCIS are used in the junior high schools. All adopted materials were trial taught for one or two years and evaluated by a teacher committee before Board of Education adoption. The Science/Health Coordinator, Environmental Education Consultant, and Department Heads at the five junior high schools within the district were all heavily involved in the development of this program. Since the first adoption thirteen years ago, all basic units have been packaged centrally and shipped to teachers on a set schedule with each classroom receiving four basic units each year. Supplementary unit kits are available at any time.

In all of our development and implementation work, the administration has been very supportive. They have provided exemplary budget support, participated in inservice training, and included science lessons among those they observe and evaluate. They have consistently seen the need to support summer projects for writing new units and revising existing ones. Other support for our program comes from Northern Illinois University and Governors State University with on-going teacher courses specifically related to the curriculum. Local PTAs collect materials, donate equipment and present a positive attitude toward process learning as well.

Initially, two teachers per school participated in a one week summer program. Along with the principals, these teachers were the basic implementors at the school level. Even, now, 13 years after our beginning, each year a new or revised unit is implemented and a one to three hour training session is planned for all teachers who will teach the particular unit. As a result of our program and emphasis on science education, there is now a general awareness that elementary children need first-hand experiences to learn science and that children are not ready to internalize abstract concepts.

Generally, in science, students are heterogeneously grouped although in certain cases there will be some departmentalization at the intermediate levels. Handicapped children are mainstreamed into the science program where appropriate. Student attitude toward science remains very high with 76% of the students continuing beyond the minimum science requirements in high school.

The Schaumburg Science Curriculum has been designed to satisfy four basic goals:

1. Stimulate children's curiosity about some part of their world and encourage them to learn more about it.
2. Create flexibility and creativity in thinking.
3. Improve use and understanding of science process skills.
4. Seek, through experimentation, explanations for natural phenomena.

The skills of inquiry, observation, measurement, classification and deduction are an integral part of the Schaumburg Science units. But, they are not the total scope. No unit aims solely to teach individual skills and units are not intended primarily to illustrate particular concepts or processes. Instead, by presenting interesting problems and real materials to explore, the units invite children to extend their knowledge, insight and enjoyment of some part of the world around them.

Throughout the program there is a strong emphasis on critical thinking and processing skills. Seeing alternative ways of approaching a problem and selecting what appears to be the most sensible solution is a prerequisite for dealing with the future and its unknown challenges. Rather than merely learning about science we want students to use their knowledge of science to make decisions about problems of their own and of society. Generally reference is made to ecological/environmental issues, energy related topics and other science related social issues. At present, the Junior High Department Heads are considering including societal issues and problems in all the 7th and 8th grade curricula as well. In the elementary grades the health units presented each year include societal issues like water quality, eye safety, choking techniques, C.P.R. and drug abuse. One example of using societal issues is the 7th grade environmental education unit where students are asked to design a human community that best exists with the natural habitat. Social/cultural relevance is an area that has been indirectly incorporated in the program and is viewed as a joint effort in coordination with the social studies curriculum. Science is part of culture and would not exist without culture. We feel it is important to recognize this. Other units have been designed with sections for teachers titled "People to Know" and "Places to Go". These provide suggested career opportunities related to the unit being studied. Also, there are opportunities to bring in individuals who have careers in the various areas of science.

The health unit at each grade level deals with pertinent health issues. These issues include value, ethical, and moral considerations of science-related social issues. Other areas of the curriculum involve ethics and social issues as well. This usually depends on grade level, maturity and nature of the study and the students. The basic thread throughout the health units is that children are responsible for their own fate. The hands-on approach to the entire curriculum helps point out the cause and effect children have on their environment. For instance, students study their own strength and heart rate and how these factors can be changed through systematic exercise.

The observatory and nature center are used by local adult organizations as well as our students. Not only does the community use our facilities, we use the community. Some units have been developed around the community and local environment. Examples of these units are the 4th grade Brine Shrimp and Environmental Health Unit where a filmstrip has been developed to show local water filtration systems and the second grade Rock to Soil unit which studies local soil types. We obtain samples during field trips to the nature center.

OVERVIEW OF ELEMENTARY SCIENCE UNITS

(supplementary skill units are used in each grade level after they are introduced)

GRADE LEVEL	REQUIRED UNITS	SUPPLEMENTARY UNITS	SUPPLEMENTARY SKILL UNITS
K	Growing seeds Hot and Cold Soup to Nuts	Nature Hunt Shadows Egg to Chick	Geo Blocks
ONE	Me and My Senses Balancing Weather Butterflies	Dinosaurs Snails Snow and Ice Magnets	Junk Learning Magnets Water Plants Tangrams
TWO	Life of Peas and Beans South and Ears to You Rock to Soil Eye Spy	Outdoor Fun Balances Air Heat	
THREE	Plant and Animal Responses Whistles and Strings Looking Up About Ourselves	Plants in the Classroom Weeple People Drops, Streams and Containers Simple Machines Wind Optics Observatory	Mirror Cards Sounds of Music
FOUR	Mystery Powders Environmental Health Clay Boats Small Things Brine Shrimp	Differences in Living Things Plant Puzzles Butterflies Structures Animal Activities Plants in the Classroom Senses	Peas and Particles

FIVE	Rocks and Charts Environmental Awareness In-Digestion Batteries and Bulbs Environmental Awareness	Airplanes Batteries II Bones Ice Cubes Nutrition/Dental Health Consumer Health Decisions Flexibility and Strength Colored Solutions	Attribute Games Mapping
SIX	Behavior of Mealworms K.P.Duty Have a Heart Astronomy 6th Grade Family Living	OBIS Cards Crayfish Birds Earthworms Optics Observatory	

OVERVIEW OF JUNIOR HIGH SCHOOL SCIENCE UNITS

SEVENTH GRADE

REQUIRED	OPTIONAL
Matter and Energy	
Introduction to the Lab (IH)* Matter, Matter Everywhere (SPIES)	Sink or Float (ESS) Balloons and Gases (ESS) Heating and Cooling (ESS) A Matter of Heat (ISCS) A Matter of Speed (ISCS) Phases of Matter (IH) Using Chemistry (IH)
Life Science	
Cell Study (IH) ECOS (SCIS)	Beans and Biology (IH) Euglena (IH) Daphnia (IH) Earthworms (IH)

EIGHT GRADE

REQUIRED	OPTIONAL

Earth Science

Crusty Problems (ISCS)
Winds and Weather (ISCS)
Local Geology (IH)
Mapping (IH)
Soils (IH)

Physical Science

What's Up? (ISCS)
Forces at Work (ISCS)
Electricity (IH)
Light and Optics (IH)
Sound (IH)

* IH = In House Produced
SPIES = Silver Burdett SPIES Program
ISCS = Intermediate Science Curriculum Study
ESS = Elementary Science Study
SCIS = Science Curriculum Improvement Study

In the 7th and 8th grades, where class periods are daily for approximately 45 minutes, students study a semester of chemistry, earth science, physical science and life science and a semester of health. The single most important criterion for excellence exhibited by the program is developing an understanding of information and concepts from a wide variety of topics selected from the life, earth and physical sciences. There is no one set of basic science topics for elementary instruction. Since no science content is truly essential, a variety of topics may be used to help develop skills in generating, categorizing, quantifying and interpreting information from an environment. This variety of topics may be used for the sole reason that they are interesting to students at a particular age. The uniqueness of the sequence of instruction is that there is no sequence. By this I mean **content** is secondary to the **process** that is used and process is an integral part of the program. The sequence is irrelevant. We can teach students to observe, inform, and predict regardless of the order or presence of specific science content in our curriculum.

The K-6 curriculum is generally taught in self-contained classrooms by generalist teachers. In 7th and 8th grades, science is taught by teachers trained in science. Regardless, the teacher's role, as with any area of the curriculum, is a critical one. Teachers spend significant amounts of time in lesson design and the evaluation of both program and self. The degree to which teachers prepare materials and instruction makes the difference between our highly effective curriculum and failure. The essential portion of our teacher's role is providing all students with an inquiring, hands-on approach in all science activities. Facilitating laboratory activities and leading discussions interpreting data occupy much of a teacher's time. Teachers ask many probing, extended answer questions and assist students in pursuing the validation of initial observations. This assistance frequently is by means of questions and suggestions for further investigation.

The hands-on process approach encourages and necessitates a personalized approach to the formalized program. Children interact with the environment according to their own individual make-up but, activities within the units encourage class discussion and cooperative data gathering for purposes of graphing information and formulating findings. Students work in cooperative small groups during many of our science activities.

Our students spend far more than the average time in science. Students work with science materials for 60 to 100 minutes per week in grades K-3, 150 to 200 minutes each week in grades 4-6, and 380 to 410 minutes each week in grades 7 and 8. Even though we use more time for science than most schools, we need even more time to teach science and health at the primary levels, particularly in 2nd and 3rd grade. I hope our administration will help in achieving this. We feel optimal class time for science probably would be 100 minutes each week in grades K-3, 200 minutes in grades 4-6, and 400 minutes in grades 7-8.

EVALUATION

We would like our evaluation system to reflect the **use** of scientific knowledge. This is an area that is being closely reviewed by the junior high department chairpersons and the science/health committee. It is an extremely difficult area to contend with but we feel progress is being made toward this goal. We also want our evaluation to consider the individual student's cognitive development and level of rational decision making. Most junior high school students are given a pencil and paper Piaget-type test entitled Concrete-Operational Reasoning Test. This assists in deriving thinking ability levels of students and covers such areas as: conservation of weight and volume, transitivity, Euclidean space, class inclusion, conservation of length and area, space, one-to-one correspondence, and validity. Teacher evaluations are included in each unit. Progress is underway to implement a student opinionnaire of science and health. This tool would be given near the end of each school year and would focus on the primary curriculum. Other facets of evaluation are being pursued for the upper level curriculum. Students are given letter grades just as they are in reading, social studies, English and math.

Evaluation of a K-8 process curriculum is difficult. The popular trend is to evaluate by pencil and paper tests stressing facts and concepts. Yet, in a hands-on curriculum where process skills, the nature of science, societal issues, science applications, and group dynamics are the emphasized learning goals we need something different. To better evaluate these areas of learning a trained observer could be employed to evaluate the effectiveness and suggest modifications. Also, a longitudinal study carried into the high school would be most interesting and valuable.

Although the school district does not presently administer standardized evaluations in science, several indicators show the program has uncommon success as an elementary science program. Schaumburg School District is a K-8 district. As the high schools are separate from the administration structure, valuable and unbiased data can be gained from high school teachers and department heads. Each year for the past seven years the three high schools attended by our students have indicated that students exhibit positive attitudes toward science, expecially toward laboratory activities. In 1982, a study conducted in one of the three schools showed that 76% of our students continued science studies beyond the one year requirement. This is significally higher than the national average of around 20%. The most important evaluation is from the children who say that they like their science. **As one fifth grade teacher found this year,**

her students chose science over recess as the part of the school day best liked. Administrative support is evident through the annual budget setting practice by which accounts are set for supplies, equipment, repair and audio visuals. Their support is apparent in on-going inservice programs in science and health. This year every teacher was provided the opportunity to receive one or more hours in a specific inservice program relating to the units they will teach. Our principals believe in and support process learning.

Although the program began with **ESS** and **ISCS** units, through student and teacher evaluations the units have been revised and modified. This process of change continues constantly and reflects the need to teach energy concepts, animal care, health education and other currently relevant science topics. Through annual evaluations and frequent unit modifications the curriculum changes to meet societal needs and maintain sound pedagogy.

Principals play a significant role in influencing teachers in the development and implementation of curriculum. The district's thrust is on viewing the principal as an instructional leader as opposed to merely a manager. This is a significant philosophical stand and gives a greater responsibility, particularly in the area of instruction A principal regularly attends science/health committee meetings and principals supervise the receipt and return of science units every 9 weeks. They also supervise the evaluation of science teaching by classroom teachers.

Schaumburg District 54 has actively participated in the **Illinois Science Teachers Association** and in **NSTA**. In the early days of program development, teachers and administrators participated in these conferences with special emphasis on gathering ideas and information by attending presentations and exhibits relevent to elementary curricula. This practice continues today, but we now contribute ideas, information, exhibits, tours and presentations of our program. **Science and Children, The Science Teacher** and **Spectrum,** the Illinois Science Teachers Association newsletter, are read by teachers, the Environmental Education Consultant and the Science/Health Coordinator. Occasionally permission is obtained to duplicate articles for district-wide distribution. A secretary and two science materials center clerks provide special support for our 800 teachers as well.

Each of the five junior high schools has a Science/Health Department Head with released time to perform building duties and assist teachers in elementary schools that feed into their junior high school. There is an Energy Education Consultant to assist in a special released time energy education program. The Environmental Education Consultant supervises the Nature Center and classroom tours of the Center. The Science/Health Coordinator supervises curriculum design, inservice training, the science distribution center, observatory and all administrative areas of the science/health program.

THE FUTURE

Although our teachers are committed to inquiry, process-oriented science they appear to dislike chemistry related units and those dealing with the more complex procedures. We still have some improvements to make. Like any good program, we are not fully where we wish to be; we are still evolving. Constant revision and change is planned as an on-going part of the program. Students and teachers are asked to evaluate each unit studied and units are changed to reflect their views and needs. Goals also change according to advances in understanding of how children learn, changing science concepts, and needs of the community. Although change is a continuing process, the over-all program remains relatively constant with only one or two units being revised each year. Parents are active participants in the revision and decision making process. Also, various community agencies participate in curriculum design and contribute speakers and reference materials to supplement the program. We could enhance the planning and revising process by increasing teacher input through assigning released time for one classroom teacher at each grade level to supervise minor revisions of each grade level unit, demonstrate process teaching techniques, and inservice all units. Such time also would provide teachers with time to meet with supervisors and community leaders. I hope these changes will make the program more teachable by elementary school teachers and increasingly exciting and relevant for children.

One way to insure a positive program evolution is to become more familiar with inquiry learning and Piagietian development as they relate to the concepts of science teaching. Another way is to see that unit revisions maintain inquiry/process learning and a positive approach to the teaching/learning environment. I would like to see a slow evolution that refines and expands the curriculum in areas of educational research and methodology and science conceptual development. If the curriculum progresses in step with technological and societal advances, this will be a consistently effective and relevant program that will be available to all students of all years. Another major need is in the area of general supplies and expendables. But, if there was a significant increase in budget, the best use would be in increasing personnel to work with elementary teachers. These staff members could develop teacher education packets for each unit and provide time to use them and inservice teachers.

Although teachers in the District use the program, the real problem is in more effective use of units and in developing teacher's understanding of science concepts and inquiry learning. This understanding can be assisted by increased opportunities for inservice. Inservice training is necessary to the survival of this program. The process is on-going and must continue in order to keep the program successful. This year every teacher will receive one or more hours of inservice relating to a science/health unit taught. Also inservice for every basic unit will be provided to teachers at the 4th, 5th and 6th grade level.

We offer several methods of teacher inservice. After school, two hour inservice sessions are provided to study specific science units or topics. Released time inservice sessions are scheduled to present revisons or specific unit teaching suggestions to entire grade levels. College courses are offered to teach science concepts, teaching methodology, and to study units in depth.

If we wanted the program to fail, we could emphasize the development of science facts and concepts in place of process skills or buy a typical science textbook. Eliminating individualization for students and intensive and ongoing inservice on teaching strategies for teachers would also be devastating. A school wishing to implement our program needs a person in charge of science and, a district with five or more schools probably needs a centralized refurbishing system to insure the smooth and efficient distribution of kits on schedule. Without this timely distribution, you cannot guarrantee that teachers will have adequate materials to teach science.

Without extensive inservice, you cannot be sure they will teach as intended. Also, the science program should be designed to service teachers, providing them with the knowledge and materials to teach hands-on science. I hope this would promote the enthusiasm that is so essential to a vital science curriculum.

Teachers new to our system should have a firm understanding of child development with emphasis on thinking skills. Also, teachers should have adequate experience and knowledge in basic science concepts and the scientific method. Teachers need more than content; they need to have experience doing science and working with science materials in a relatively non-directive environment. Teachers in our program also need classroom management skills, scientific literacy, a knowledge of children's thinking abilities, and personal flexibility. Science literacy, including an understanding of the nature of science, its history, and meaning, comes about through interaction with both materials and ideas.

Several of our teachers are on the teaching staff at the Museum of Science and Industry. Others have been asked to serve on committees and advise in the development of science programs for other school districts. Five teachers are active in working with publishers developing science/ health trade books while three teachers regularly teach college courses in science education methodology. Also, our teachers are active in the **Illinois Science Teachers Association** and the **Environmental Education Association of Illinois**. All of these activities were possible through association with the Schaumburg program.

Our action and long-range thoughts are well demonstrated by our special energy program. Each year 260 4th, 5th, and 6th graders are chosen for a special study of energy. During the year they meet weekly with a special teacher and, in groups of 60, they each spend a week during the month of May at a camp in Wisconsin. There students are given an "energy allowance" which must cover all their energy needs. Students must decide how to spend their energy and can save by walking, cooking over an open fire, or taking cold showers. On returning to their schools, they teach their classmates what they have learned, extending the program to all 11,000 students in the District's 23 elementary schools.

Originally supported with Federal funds, the District now spends $65,000 of local money each year to continue the project. Students, teachers, and the community feel it is a worthwhile effort which helps students think, debate, and decide how energy problems affect us and can be solved. This program is further evidence of the committment our district has to an outstanding elementary science program. We wanted a good program, we developed and implemented it, and we will continue to provide quality science education to the students and citizens of our community.

Chapter 12: Delake Primary Science

By

Sally Stewart
with
Gary Winter

Delake Elementary School
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Lincoln City, Oregon 97367

Lincoln city, a community of 5500 people, is home to people from a variety of socio-economic levels. The average family is lower middle-class with a generally positive attitude toward education. This is a solid community mixed with a large transiant population. Our main industries and income, tourism, lodging, and fishing, insure us of many unique individuals such as artists, entertainers, and eccentrics. Because of high unemployment in these areas the mood is not always optimistic. Delake, a small school built in 1925, has only seven teachers and 160 children in the primary grades. We have no special science areas but a creative, optimistic, friendly mood prevails among both teachers and students. A strong focus on each individual child is the norm.

At present there is no district-wide curriculum program in science except for the availability of a wide range of science kits and materials through the Instructional Media Center. These kits emphasize **Elementary Science Study (ESS)** units. The District is currently involved in a two year science development program which will continue to emphasize discovery type kits and not text books.

This lack of an organized curriculum in science is a serious problem which must be overcome if we are to truly succeed. We have a strong need for the development process which has already begun. At present, each science program is up to the individual teacher. So, both textbook and hands-on approaches are implemented throughout the district depending on the individual instructor. We have a great deal of freedom except for normal constraints imposed by our society. These constraints cause us little problem but we are cautious.

OUR PROGRAM

My husband, Gary Winter, has been my greatest inspiration in developing and implementing my current science program. Gary, with a masters degree in Biology and a strong interest in the outdoors, is also a teacher. We have developed many science units together. Since during my free time I spend a lot of time in the outdoors, I feel its important to bring the outdoors and my interests into the classroom. There I am able to share and expand in many science related areas. Support from the administration is always available and is evident in their recommending me for the Search for

Excellence. I feel that the freedom given me to design my own science program, the availability of materials, and the opportunity to develop a model for other grades has been a positive attribute in the development of both me and my program.

There is no science supervisor, however the district's curriculum coordinator has a biology background and serves as a helpful advisor in the field of science. She is the chairperson for the science curriculum committee responsible for the district's two year adoption program just getting underway, made up of teachers and administration working together.

I want to create an atmosphere where students develop a comfortable attitude toward science. I want to expose the children to many areas of science such as marine biology, volcanos, dinosaurs, magnets and electricity, problem identification and solving, patterns in nature, insects, fish, energy, recycling, nutrition, and the human body. In doing so, students will develop classifying skills such as sorting and graphing and approach science through inquiry. Developing an awareness of their environment and learning of recycling, field trips and study of animals is important as well. In the process they will be exposed to different careers in the field of science.

Students should come to want to protect the environment for future use and enjoyment. They must be willing to make personal sacrifices for this goal. As they learn this, they will understand the human impact on the environment. They will understand pollution drawing a balance between a healthy environment and use of resources; human wants vs. human needs. While the social context is not a central focus, students do use their knowledge in problem solving activities usually involving manipulatives.

I like children to be involved actively and responsibily in the classroom. So, children are responsible for maintaining several aquaria and usually are involved with our ongoing problem solving table which allows free exploration working with puzzles, tangrams, other manipulatives. I always have a special unit science center focusing on the unit that is being studied. Shelves contain math manipulatives such as colored rods, jewels, pattern blocks, unifix cubes and other materials. Many of the materials are low budget items that I or the kids have brought in. These include leaves, lava, skulls, and bones.

Usually, I distribute materials myself but children are responsible for clean up and returning the materials to the place they belong. Often I will assign one person to be in charge of organizing those materials and making sure the materials have been returned. My class is a combination of 21 first and second grade students with abilities ranging from beginning readiness to advanced students. Most of the children have a positive attitude toward school, especially math and science.

I have involved the community in my classroom by including guest speakers as visitors and classroom visits outside the school that are involved in the science unit we are studying. By involving professional people in science (marine biologist, forester, bird expert, dentist, marine mammal expert, x-ray technician) children learn of careers, the excitement of science, and new ideas.

I present ideas on endangered species and why we need to protect them. Native Americans, their life style past and present and what will happen in the future are discussed as well. In all cases, value, ethical, and moral considerations of science-related social issues are discussed. I also use Native Americans legends to explain scientific phenomena. Indians had explanations for volcanos, human creation, and animal characteristics which were based on their explanation of natural phenomena. These explanations are useful as the students learn to make-up their own explanations. In the process, I want students to see that humans are the caretakers of the earth and are responsible for their own actions. They also learn science is a human activity and they can do science themselves.

Frequent field trips to local businesses, nature walks, and other points of interest such as the beach, nature conservancy area, or state parks are taken. We also have frequent contact with 4, 5 and 6th grade students at our sister school, Oceanlake. Students tie the environment and community into the science unit by bringing them into the classroom and going out of the classroom to explore these areas. Students study tracks by making tracks on the beach, or inviting a dog, rat or other animal into the classroom to make their tracks.

Last year, our general schedule was:

September - plants, whales, seasons (equinox)

October - mammals, animal tracks

November - volcanos

December - seasons, culture study of Mexico

January - energy, magnets, recycling, begin two month study of body

February - nutrition, study of human body

March - Native American culture

April - dinosaurs, reptiles, amphibians

May - Marine Biology, fish, environmental day

June - Marine Biology

ATTENTION: tangrams, pattern blocks, attribute games and manipulatives of this sort are available in the classroom all year. Many of these are from **ESS**. I work hard to blend each unit into another, helping the students build and expand on past and present experiences.

My curriculum is not rigid. This flexibility allows for changes that might occur in the outside world which could become immediate lessons. Science units should not be isolated anymore than one aspect of science is independent. Science is science and I want students to remember that. I also want science to be presented in a way that is relevant to the students' own experiences. So, we study volcanos, Mt. St. Helens and the Cascades; personal health awareness, awareness of the health of their immediate environment and the need for a balance in nature.

Our science program is very individualized and personalized with students working with partners and with small groups and a lot of hands-on materials. Many of my activities involve thinking skills. I try to instill a sense of excitement in the children through the use of many hands-on activities emphasizing individual abilities. Science is taught in a way that is relevant to present as well as future situations. Students learn how budget cuts influence science education, environment, and community and discuss science in relation to human welfare.

My interest in the environment and outdoors strongly influences what I teach. I am interested in endangered species, birds of prey, health awareness, and equity in science education and careers. I also stress the value of native american culture, knowledge, and tradition. We emphasize the study of plants, animals and health with a special focus on the relationship to science of art, cooking, and Native American culture. We also study the marine environment. All of our units include aspects of problem identification and solving, graphing, energy, recycling, and career awareness. Throughout the year the students are encouraged to give input regarding what they would like to study. This strongly influences many of the science units I present. The students are continually asked to evaluate their progress verbally and decision-making is included in every subject.

An Example of a Unit on Tracks and Tracking

This five day unit may be spread out throughout a two or three week period.

Day 1:

Introduce tracking through examples and mystery pictures which encourage inquiry. We play a tracking concentration game.

Day 2:

Invite dog or other animals to school to cast tracks and make prints. Children cast their own hands and feet.
We discuss differences between flat-footed animals and animal tracks such as dogs, cats, and hoofed animals.

Day 3:

We walk to the beach looking for tracks and making tracks. We make plaster casts of several prints to take back to the classroom. While at the beach we view tracks after running, skipping, walking, and hopping.
We play an inquiry game to figure out how someone was moving. In this game, everyone hides their eyes while one person makes tracks. Then, the group tries to determine how that person moved.

Day 4:

Students begin writing tracking books using concentration cards. They copy tracks into a small book of their own.

Day 5:

We read a tracking story where children make tracks of animals in the story with foam stamps.
Students finish their tracking books today as well.

The unit also includes a field trip to a wooded area where children find tracks of animals and identify them by using information from past experiences and their tracking books.

My teaching strategy has been influenced greatly by Madeline Hunter. I insist on an intellectually open classroom where each student is manipulating his own material but able to talk to others or work cooperatively.

This is the only way which makes sense if I am going to meet individual needs and abilities. To provide variety and new experiences, I also structure each day to include some large group instruction as well as totally individualized learning. While I monitor what students are doing and adjust my teaching as necessary to achieve my goals, I work hard to model to my students the attitudes and involvement I wish them to have. I want them to enjoy science, to ask good questions to be accepting; I want them to investigate and observe. So, I make sure that in my own teaching I am enthusiastic; asking good questions, and investigating openly. I also spend much of my time observing students rather than bothering them while they are learning. I encourage children to learn by observing and interacting with them and by letting them know I respect and value what they are doing. I assess and evaluate what they are doing by observing. I know what I want them to be **doing** so it is easy to see if they do it.

In the process of modeling and observing I find it is critical that I avoid most pencil and paper activities. Students want real equipment which allows them to identify and solve science problems. They don't want worksheets. Textbooks are also out as they are strictly academic and do not model science as investigation. I also have found that, if I want students to learn to make good decisions, I must avoid making decisions for them. I try to give them choices in what activity to do, how to do it, and when they are done. My role is to encourage them to explore and probe as deeply as possible. As I do that, I work hard to provide adequate wait-time after I ask questions. Too little wait-time is probably the most certain way known of stopping inquiry. Actually, a required text book approach might kill the whole program just as surely.

Since text materials are not appropriate, I have developed my own units using materials from the **ESS** kits. I also read **Science and Children** and I implement activities I read about. Since the magazine comes every month, I usually get at least one new idea each month. I have developed Current Science Activity Guides for each basic activity I do. While we usually are scheduled 45 minutes a day, approximately 4 1/2 hours per week, this time is flexible and not static. Although traditionally science is taught in the afternoon, I have found that children respond positively to science during our 45 minute block before lunch. The hands-on and visual material of high interest usually gets them actively involved. If more time is needed on a particular lesson I am flexible in my schedule. I will move afternoon activities to the morning and have science during our 2 hour block in the afternoon. Many primary elementary teachers teach science rarely because they lack this flexibility and fear science. I feel that my science program is unique because it is flexible and continually an expanding part of my total curriculum.

EVALUATION

I evaluate myself and the program through personal observation, clinical supervision from my principal, and feedback from students. Students are evaluated on an individual basis through my own personal observations, questioning strategies with students, graphing, and participation in discussions. As I hope to continue being open to change, I also hope my evaluation reflects changes in my curriculum and student needs. In addition, my husband has been a sounding board for providing constructive criticism for ideas I've come up with. Evaluation of me and the program is far more meaningful than evaluating student achievement. If I do my job well with a well-designed curriculum, students will learn and do science. I would love to keep track of student progress in high school so I could see what long-range impact we are really having.

Parents are involved in field trips and our environmental day. I've worked with parents and helped prepare them to teach outdoor lessons to small groups. During cooking lessons the parents will occasionally assist as well. The administration is very supportive as well. They nominated me for the "Search for Excellence" and view science as an important part of the curriculum. This is evident in the establishment of the science adoption committee. My administration encourages involvement between schools and the community and encourages the use of teaching methods giving me the flexibility to create a science program with which I feel comfortable. The principal is supportive of science and encourages the need for community and specialist involvement. He is willing to help set up programs and work on committees.

The District's Instructional Media Center supports me by providing many materials and ESS kits. The curriculum library is available to us and the Science Curriculum Committee is currently developing criteria for the selection of suitable material in light of current budget restraints.

Our expenses are minimal and they usually come out of my own pocket. This might change after the new science adoption is decided upon. I would like to make changes in many activities but due to time and financial restraints I am unable to do so right now. I could use microscopes, a greenhouse, an outdoor nature area, and more trees and a garden. The outdoor area is very limited at my school and confines many of our activities. I also need more room to expand my classroom and a larger outdoor area. A room for storing science supplies, and lab space would be useful as well.

NSTA has been a strong influence in providing research, sharing activities, and publishing journals such as **Science and Children**. **Science and Children** is my primary resource for establishing my science curriculum. The school subscribes to **Science and Children** and I receive my own personal copy as well. I insure relevance to the children by providing hands-on materials, with many inherent problems, sharing my own interests and collections, and letting students pursue their own interests, and abilities. I read about science and science teaching as a way of keeping up with the world and I like students to know it.

I could really do more if the school could provide more teacher aide time. We still need more ESS kits as well. Our teachers need help as well with knowledge, confidence, and appropriate teaching strategies. Science needs to be emphasized more in high school and college to develop a comfortable attitude among teachers. My personal familiarity with science has come primarily through personal experience and contact with the outdoors. I feel that outdoor education at an early age is very beneficial in developing a positive attitude towards science and the environment as an adult.

Teachers need a general working knowledge of science, practical experience, and an enthusiasm to try new things and take risks. If teachers had more knowledge of science and the nature of science; if they had more success and experience with doing science, then they would teach more science. If they taught that science in an intellectually free atmosphere designed with an understanding of how children learn, then we would have more learning of science. With more learning, our citizens will better appreciate science, teaching, and teachers.

Chapter 13: Elementary Science Program

By

Cynthia Hrebar and Harold Pratt

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The Jefferson County School District was formed in 1951 when 39 separate, small, independent school districts were unified as the first reorganized district in Colorado. The county is large (783 square miles), running north-south beginning at the western boundary of Denver and moving just into the mountains on the west. The total population of the county is 387,000 with a school population of 76,529 mostly white students.

American Indian or Alaskan Native	383	0.5%
Asian or Pacific Islander	1,399	1.8%
Black, not of Hispanic origin	481	0.6%
White, not of Hispanic origin	70,607	92.3%
Hispanic	3,659	4.8%

The county is generally a middle-class, bedroom community with two major industries, the Martin-Marietta Missile Aerospace Corporation Coors Brewery. Although the population of the county is growing, the school population is declining slightly after having peaked at almost 81,000 about four years ago. The center of the county is declining in population while the north and south ends continue to grow and new schools are being constructed in both of those areas.

A NEED TO CHANGE

The District elementary science program prior to 1973 consisted mainly of **Elementary Science Studies (ESS)** units, some **Science Curriculum Improvement Study (SCIS)** and a few **Mini-Mast** units. This program was hands-on and inquiry oriented with no textbooks used except as resources. The units for each grade level were specified and teachers received inservice assistance in content and process. After initial implementation in 1969, inservices were conducted on a strictly voluntary basis. Consequently, many teachers who were uncomfortable with or uninterested in teaching science received no assistance. In 1973 new District goals and student outcome statements were adopted by the Board of Education. These statements described what the Jefferson County community thought "a graduate of our schools should look like, act like and be prepared to do after leaving high school." The existing curriculum needed to be modified to correspond to these goals and outcome statements since the existing science program was deficient, especially in the area of life, health and environmental sciences.

In addition, accountability was beginning to have an impact on school districts and program developers. A more precise definition of expectations placed on teachers and students was needed to assist teachers in better understanding open-ended, inquiry-oriented science activities. Thus, a systematic approach to the science curriculum which would include performance objectives clearly defining expectations of students needed to be developed.

PROGRAM DEVELOPMENT

The development process followed the District procedure described by the Curriculum Development Process. This well-defined process includes: needs assessment, curriculum objective statements, curriculum writing, pilot testing and evaluation, field testing and evaluation, and district wide implementation. Essentially, piloting evaluates the quality of the materials and field testing determines potential problems with implementation. During each stage of development the revised program was presented and reviewed by the Elementary Curriculum Council.

Harold Pratt, Science Coordinator, and Marge Melle, Science Resource Specialist, planned, developed, coordinated and implemented the Jefferson County Revised Elementary Science Program with assistance from teacher writing teams, special education consultants, the health coordinator, and the environmental education coordinator. Ideas and help were also received from the outdoor education coordinator, inservice teachers, pilot teachers, and field test teachers during development.

Following completion of a needs assessment and establishment of program goals, the revised materials were developed by a team of teachers and program developers during the summer of 1974. The teacher writing teams were crucial in generating support and enthusiasm among other teachers in the District. Experienced science teachers piloted these materials during the 1974-75 school year. Approval was given by the Board of Education in April 1975 to proceed to field test. Schools were selected on the basis of interest, community characteristics, school construction and school organization.

After field testing, the Board of Education approved full-scale implementation of the Jefferson County Revised Elementary Science Program in February 1976. In preparation for this, principals and our superintendents attended an inservice in March of 1976 to become acquainted with the philosophy as well as the implementation requirements including cost, inservice, equipment acquisition and storage of materials. That summer the field tested curriculum was refined, the final guide printed and equipment ordered. In the fall the inservice cadre was trained and teachers who would teach the program attended a preservice session.

IMPLEMENTATION: DEALING WITH CHANGE

Change is a process and not an event. Because of this assumption careful attention was given to those involved with the change through initial implementation and continued maintenance efforts.

Implementation was divided into three phases because 72 schools were involved and extensive staff development activities were planned. Phase I schools began implementation in January 1977, with Phase II school following in September of 1977 and Phase III in January 1978.

Total implementation was planned in collaboration with Gene Hall at the Research and Development Center for Teacher Education, University of Texas at Austin, using the research findings of the Concerns Based Adoption Model. (Hall, Wallace and Dossett, 1973; Pratt, Melle Metzdorf and Loucks, 1980) Care was taken to address the various concerns, both personal and management, that teachers would bring both to the preservice sessions and the three full days of science inservice that each teacher would attend.

PHILOSOPHICAL PERSPECTIVE

Program Developers supported the results of current research in the field that indicated an elementary science program must match the physical, mental social and developmental characteristics of the elementary child. If one accepts this philosophical premise then an elementary science program must embrace a hands-on inquiry approach in which children:

* **Experience** natural phenomena

* **Develop** concepts, and

* **Have** an opportunity to apply it to their own lives.

This approach to science fosters the acquisition of the processes of science as well as the rudimentary concepts needed to become technologically literate adult citizens for the year 2000. There also must be a balance between the cognitive and affective domain so that the "whole child's potential" is stimulated.

This philosophical orientation dominated all decisions in developing the Jefferson County Revised Elementary Science Program. Thus, the program is concrete, interactive, exploratory, applicable, relevant and success oriented.

GOALS AND OBJECTIVES

The goals of the Jefferson County Science Program are designed to:

* **Develop** scientific and technological literacy for all students.

* **Encourage** students who are likely to pursue science-related professions to acquire the knowledge appropriate for these needs (professional preparation).

* **Prepare** individuals to use science for improving their own lives and coping with an increasingly technological world (personal needs).

- **Produce** informed citizens prepared to deal responsibly with science-related social issues (societal issues).

- **Give** all students an awareness of the nature and scope of a wide variety of science and technologically related careers open to people of varying aptitudes and interests (career awareness).

- **Develop** in students the decision making skills which enable them to apply scientific and technological knowledge in solving personal and societal problems.

- **Promote** the student's self image and a positive attitude toward science.

- **Provide** science instruction that matches students mental, physical, social and emotional growth and is consistent with their future plans.

The intent of the elementary science program is to provide concrete, first-hand experiences for students so that they may begin the process of becoming scientifically literate citizens. Because a child's mind changes in the way it operates and does not simply increase in capacity as it matures, the 3-6 outcomes are very concrete and demand direct student observation and participation. Inquiry is the backbone of the program. By the end of the sixth grade a student should be able to:

- **Observe** and describe a simple event using more than one sense.

- **Record** and share observations with others.

- **Classify** a set of objects.

- **Collect** and organize simple data.

- **Set** up a simple experiment to answer a question.

- **Read** scientific materials critically.

- **Demonstrate** a basic understanding of the function of the ecosystem and his/her relationship to it.

- **Demonstrate** a basic knowledge of physical science concepts.

PROGRAM DESIGN

The Jefferson County Revised Science Program is currently in place in 74 District schools. The District-developed, hands-on, interdisciplinary inquiry program for grades three through six consists mainly of adapted **ESS** and **SCIS** units, parts of the **Biological Sciences Curriculum Study**

REVISED ELEMENTARY SCIENCE CURRICULUM CONTENT STRANDS

	Health Science	Physical Science	Environmental Science	Earth Science Astronomy
Grade 3	Dental Health (local) Your Senses (local)	Structures (ESS) (OBIS)	Populations (SCIS) (OBIS) Ice Cubes (ESS)	What's Up There? (local, using our planetarium)
Grade 4	Bones (ESS)	Mystery Powders (ESS)	Environments (SCIS) and Mealworms (ESS) (OBIS) Crayfish (ESS)	Rocks and Charts (ESS) Operation Sky Watch (local, using our planetarium)
Grade 5	Human Body Systems (BSCS) Reproductive System (a Family Living unit) (local)	Batteries and Bulbs (ESS)	Communities (SCIS) and Small Things, (ESS) (OBIS)	Space: The New Frontier (local, using our planetarium)
Grade 6	Nervous System and Decision Making (Drugs, alcohol & tobacco) BSCS and local	Optics (ESS) Kitchen Physics (ESS) Gases and Airs (ESS) (optional)	Ecosystems (SCIS) (OBIS) Ecosystems Supplement (Outdoor Laboratory School) Microgardening (ESS) (optional)	Tools of Astronomy (local, using our planetarium)

(BSCS) and locally written units for health and astronomy. Two Outdoor Education Lab Schools and a planetarium are an integral part of the program.

Four content strands are imbedded within the program: health, physical science, environmental science, and earth science/astronomy. The curriculum is not written on a spiral basis, rather, each unit is discreet within itself. All strands are required to be taught since the program has been approved and adopted by the Board of Education.

The District science guides, which outline the activities teachers are to use from the commercial (ESS, SCIS, BSCS) guides, consist of one notebook for each grade level. These guides also contain equipment and media lists at the beginning of each unit, suggest activities to assess student progress, include a complete set of worksheets, and have materials and equipment ordering information in the Appendix. Computer application and integration within the existing curriculum is currently underway with at least 15 computers in all elementary schools.

Because the Revised Elementary Science Program is a District-wide program, there is a great diversity in the way in which materials and equipment are managed. Some schools maintain central storage facilities with a system for ordering and retrieval. Other schools house materials and equipment on a team, grade level or classroom basis. On the district level a central warehouse stores materials that are required and frequently used in the program. The average cost for replacing consumed materials is $2.00 per pupil per year. The District has a verbal agreement with a local biological supply company to provide live organisms at a reasonable cost.

SCIENCE 240 MINUTES A WEEK

Science instruction is a critical and essential component of every elementary student's basic instructional program. Board of Education mandates that all elementary school children in grades four through six receive 240 minutes a week in science instruction and in grade three receive 160 minutes each week.

THE CLASSROOM SCENE

Teachers provide a variety of learning opportunities based upon students' needs and learning styles. These range from learning centers and small-group work to large-group direct instruction and discussion. A majority of learnings activities are structured so that students are cooperatively interacting with each other, exploring, recording, drawing conclusions, and problem solving. The cooperative learning goal structure is actively encouraged and is a direct result of the Science Department's involvement with the research of David and Roger Johnson (University of Minnesota, Cooperative Learning Project).

Teachers delivering the Jefferson County Revised Elementary Science Program state the objective for the day, review previous work, and arouse motivation or personal interest. They set the lesson by explaining the task, stating expectations, and organizing management of materials and equipment. Teachers facilitate the lesson by moving from group to group, answering questions, asking questions, waiting for student responses, and confronting individuals or groups. Concept development is encouraged by soliciting results of experimentation, providing information and definitions, and eliciting concepts. Closure is provided while summarizing concepts to personal lives. Teachers also assess individual or group work.

A visitor in an elementary school would see small groups of students working together observing and exploring in the regular classroom or in the outdoor classroom while measuring, manipulating, questioning, organizing data, evaluating data, and developing concepts. In large-group discussion students might be sharing data, developing concepts, applying concepts, and drawing conclusions. A visitor would not see a silent classroom with no interaction.

A CRITICAL FACTOR: INSERVICE

A Jeffco teacher teaching the revised science program needs to be a facilitator rather than a lecturer or authoritative disseminator of information. During the initial implementation phases teachers receive training in the program content as well as processes to deliver the program effectively.

This inservice program started with a preservice session held after school in the individual buildings in which teachers personally received a copy of the new guide, an introduction to the revision, a schedule of inservice meetings, and an opportunity to discuss the changes and ask questions. Two to three months later the first of these all-day inservices was conducted at a central location. The next two inservices were scheduled several months later to coincide with the schedule teachers would be using in teaching the new program. The time between the preinservice session and the last of the three inservice days was over 13 months.

But what about teachers entering the system after implementation? The Science Department addresses this need by continuing to conduct intensive hands-on inservices in which teachers receive at least three days of inservice in use of the program. Teachers who are new to the District or who have changed grade level attend the science inservices over a three-month period. Trained inservice leaders who are practicing teachers review philosophy, grade level units and content, engage participants in hands-on activities from the units, share management and organizational tips, identify assessment activities and introduce generic teaching strategies.

Through extensive inservice as well as through prescriptive guides, teachers have gained confidence in their ability to provide science instruction. Now teachers spend more time with science and feel more comfortable using the out-of-doors as a classroom. This includes two Outdoor Education Lab Schools where all sixth grade students spend one week in residence.

The program developers maintain that inservice is a crucial factor which determines if a program is a reality in the classroom or merely an attractive guide on a shelf.

MAINTAINING THE PROGRAM

Although the program was fully implemented by June 1978, support for the revised program continues with science inservice for new teachers or those who changed grade level, Comfort and Caring visits, and the Instructional Improvement Process.

Each of the 74 elementary schools is scheduled for a Comfort and Caring visit by the science department staff every other year. These visits provide an opportunity for teachers and principals to ask questions, seek clarification, obtain information and voice concerns.

The Instructional Improvement Process is an exciting and intense intervension intended to maintain a high quality program. Its design is based on coaching rather than providing information or demonstration.

The Instructional Improvement Process is a year-long activity specifically designed to improve the implementation of the science program for R-1 elementary students. The process is a collaborative one whereby the principal, assistant principal, building staff and central office science personnel work together to fully implement the Revised Elementary Science Program.

Before a plan for improvement can occur, a definition or criteria for a well-implemented program are needed. Seven Key Features and Key Feature Indicators are the criteria used. The Key Features define the essential components of the program and are observable and/or measurable. Key Feature indicators designated the level of implementation along a continuum from "outside the intended program" to "best practices working." The latter delineates what ideally "should be." Instructional improvement is viewed as movement toward "best practices working."

The Instructional Improvement Process begins when the principal and staff of a school decide to enter the process. Once committed, the principal and assistant principal attend a two-day workshop to acquire knowledge, use and application of the Key Features and Key Feature Indicators. This entails simulated and actual practice using the specified data-gathering instruments and compiling individual teacher profiles.

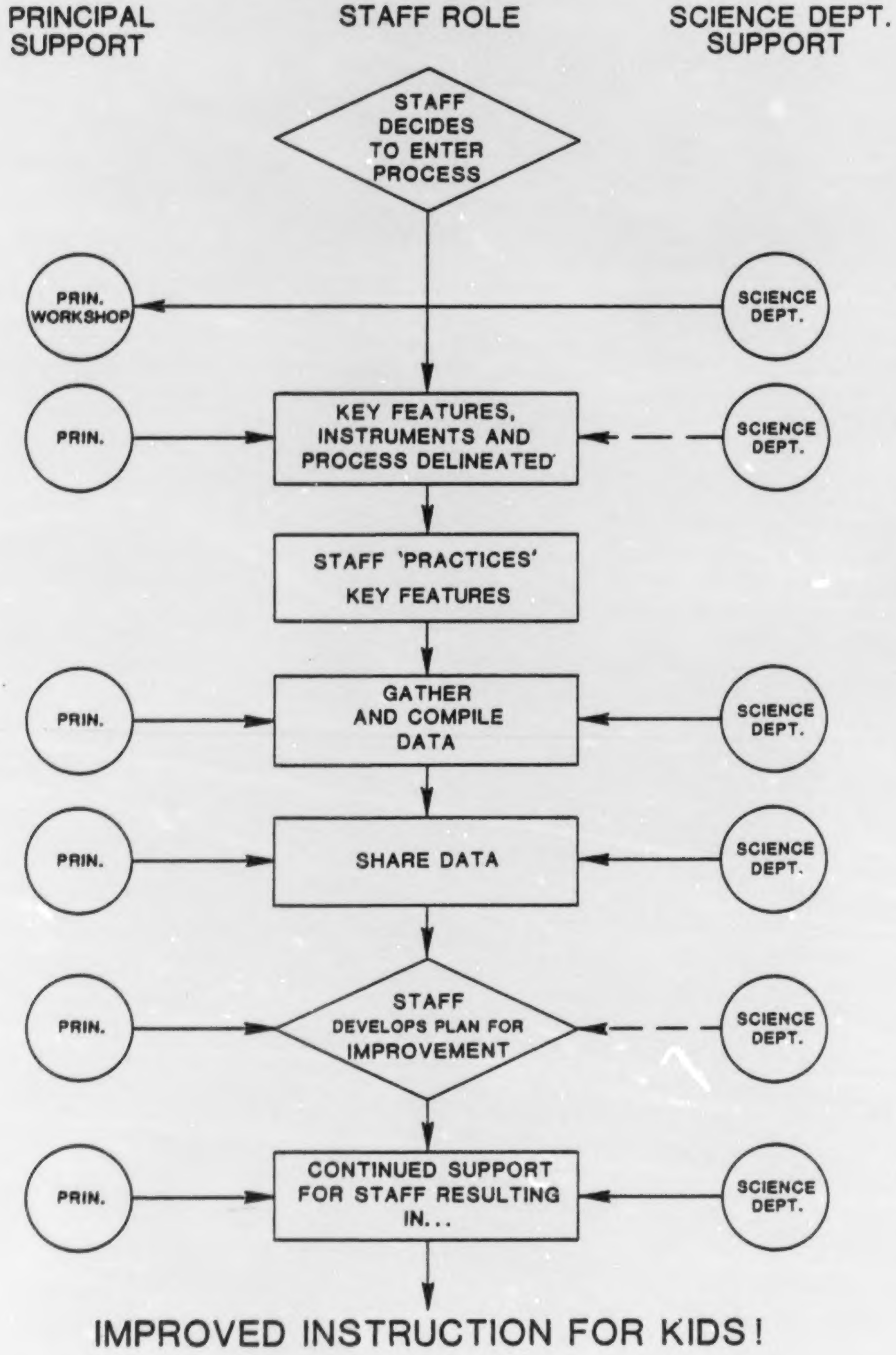
In the fall the principal, assistant principal and science department personnel jointly conduct a mini-workshop for science teachers. The Key Features and Key Feature Indicators are reviewed in relation to their classroom behavior. The purpose is to assist teachers with integrating the Key Features into their teaching.

Understanding Key Features and applying them to current behavior takes time and support. Therefore, a six-to-eight-week practice period is provided during which science department personnel meet with teachers on a frequent and informal basis to address specific needs.

Following this practice period, Key Features are monitored by the principal, assistant principal, and science department personnel through the use of classroom observations and focused interviews. After classroom observations, feedback sessions are held. During these sessions data are shared, perceptions checked, strengths identified, and suggestions for improvement discussed. The coaching technique has been favorably received and has tended to increase awareness, dialogue and trust. The Key Features have proven to be a useful and objective starting point to dialogue about program, to brainstorm alternative teaching strategies, and to problem solve areas of concern.

When all data are gathered the information is summarized in the form of individual teacher profiles which are shared with each staff member. A composite school profile is then presented to the total staff. Data are

INSTRUCTIONAL IMPROVEMENT PROCESS
ELEMENTARY SCIENCE


PRINCIPAL SUPPORT
STAFF ROLE
SCIENCE DEPT. SUPPORT
STAFF DECIDES TO ENTER PROCESS
PRIN. WORKSHOP
SCIENCE DEPT.
PRIN.
KEY FEATURES, INSTRUMENTS AND PROCESS DELINEATED
SCIENCE DEPT.
STAFF 'PRACTICES' KEY FEATURES
PRIN.
GATHER AND COMPILE DATA
SCIENCE DEPT.
PRIN.
SHARE DATA
SCIENCE DEPT.
PRIN.
STAFF DEVELOPS PLAN FOR IMPROVEMENT
SCIENCE DEPT.
PRIN.
CONTINUED SUPPORT FOR STAFF RESULTING IN...
SCIENCE DEPT.
IMPROVED INSTRUCTION FOR KIDS!

analyzed, individual and/or school targets are mutually identified, and a plan for continued improvement is developed.

The Instructional Improvement Process is a procedure that describes current program implementation, compares actual practice with ideal practice, targets needs, and establishes a plan for improvement. This fosters an increase in the extent to which the program is implemented resulting in greater quantity and quality of science instruction for students.

EVALUATION

Several types of evaluation relate to the Jefferson County Revised Science Program. These include evaluation of the extent of implementation, an external audit of the entire elementary-secondary science program, and an annual assessment of sixth grade student science achievement.

The Science Department in cooperation with the Program Evaluation Department developed a process to describe and evaluate the extent to which the revised program was being implemented in a given school (Darnell, 1979). The criteria used were the Key Features which define a well-implemented program. Descriptive and detailed behaviors for each Key Feature facilitated objective data collection.

The procedure used with Implementation Phase I and II schools was primarily evaluative and summative. Experience indicated that with the modifications incorporated during Phase III the basic process could be adopted to be formative and instructive with a focus on improving instruction for students. Thus, the Instructional Improvement Porcess, which is a collaborative, ongoing process in which principals, staff and program managers work together as a team, evolved (Melle and Darnell, 1980; Mell and Pratt, 1981).

The second type of evaluation involved a program audit. While the Jefferson County Revised Elementary Science Program has been in place for only five years, it has been recently evaluated by mandate of the Board of Education. The mandate calls for the development and adoption of "a plan to systematically and continuously review and upgrade the District's education program, insuring adequate input from appropriate administrators, teachers, students and community members."

The adopted model for this evaluation requires 1) a statement of the "desired state" based on a thorough literature search, 2) a description of "what is currently in place in the schools, 3) and identification of discrepancies between the "desired" and "actual" state and 4) an improvement plan to eliminate the discrepancies. After the last step, program development cycles into the Curriculum Development Process discussed in the section on Program Development.

The science curriculum was the first content area to be evaluated. In October 1981 the Science Department published "Goals Of A Desired Science Program As Derived From An Analysis Of The Science Education Literature" followed by the "Science Department Self Study" in April 1982. Also in April, an external audit team consisting of Colorado administrators, teachers and citizens conducted a week-long audit in 28 Jefferson County Schools. The recommendations suggested by the audit team were incorporated into a "Prospectus For Program Improvement" which was developed by the Science Department in February 1983 and adopted by the Board of Education in March 1983.

Two of the five major projects resulting from the external audit process directly affected the elementary program. These include expanding the Instructional Improvement Process and refining and updating the curriculum including the use and applications of computers.

The final area of evaluation is the Sixth Grade Science Test which is a locally developed criterion reference test completed in 1980 and administered annually each spring. The primary purpose of the test is to improve science instruction based on the assumption if you improve instruction there will be a correlative increase in student achievement. The test is designed to measure the collective achievement of sixth grade students on the objectives of the District science program over grades three through six and not to indicate whether an individual student or a group of students has mastered the elementary science objectives. There are no predetermined expectations or mastery levels of how well a student or a class of students should do on the test.

CONCLUDING STATEMENT

The Jefferson County Revised Elementary Program has been successful not because of its content, design or structure. Rather, it has been successful because of the quality of its support structure. It is broadly supported by the Board of Education who adopted it, by the teachers who deliver it and by Science Department personnel who maintain it. It is this pervasive support that allows a hands-on inquiry science program to thrive at a time when hundreds of other districts are abandoning this conceptual design.

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Chapter 14: Excellence in Teaching Elementary Science: Some Generalizations and Recommendations

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In chapter 1, Roger Johnson describes the Project Synthesis desired state for elementary science programs. Developed by twenty-three science education researchers over a two year period, the desired state reflects a number of societal indicators, foundation reports, editorials and thought pieces, and a desire for science literacy among the general public.

These criteria, categorized as Personal Needs, Societal Issues, Academic Preparation, and Career Education/Awareness, necessitate program characteristics unlike those found in traditional settings, textbooks, or instructional strategies. Also, these criteria are not well represented among standardized test items. So, it is not surprising that the twelve programs described in this monograph are not traditional, text oriented, or overly concerned with evaluating solely by means of pencil and paper tests. These programs were designed to be excellent, dare to be different, and stand out as exemplary. They are truly models from which we can learn much about designing, developing, implementing, and maintaining strong elementary science programs of which we can be proud. And, along with our pride, we can be confident that students in these programs are experiencing science directly, liking it, and carrying those positive experiences on with them. They are well on the way to science literacy as adults. Since literacy encompases understanding and appreciating science, many programs such as those would assure us of a generation of adults supportive of school science as basic and the scientific enterprise as necessary.

SOME GENERALIZATIONS

Science is being taught in classrooms using these twelve programs. While that may seem rather mundane and simplistic we feel this is a generalization worth noting; a generalization which did not arise from our prior visits to hundreds of elementary schools not named as exemplary. When we say "teaching science" we mean both time for science and teaching which reflects science as science rather than language arts or reading. We are well convinced that these twelve programs are close to the synthesis criteria, far from the norm, and well-deserving of exemplary status.

Nationally, schools report an average of twenty minutes a day spent on science. Is this self-report of required time for science an accurate measure of time really spent? We think not. Compare this to Schaumburg (Chapter 11) where they spend thirty to forty minutes each day in grades four through six and say they need still more time. Or, what does it mean when Santa Cruz (Chapter 2) has two hours each week and wants four to six hours more? While most teachers would have trouble planning and teaching more science, teachers in these exemplary programs literally say they can teach science more and still get in math, social studies, and yes, even reading. In fact, in Mesa, Arizona (Chapter 7) and in Santa Cruz, science is already integrated into reading, social studies, and math. A comparison of time spent on various subjects by programs described in the monograph and data collected from a national, random survey is interesting.

Time Spent Teaching

(In minutes per day)

	National Average	Monograph Programs
Science	20	29
Math	44	51
Social Studies	25	27
Reading	86	77

These twelve programs have cut only nine minutes a day out of reading and managed to add nine minutes to science, seven minutes to math, and two to social studies. Science is quite obviously basic to these exemplary programs.

In addition to teaching more, we feel strongly that they are teaching science as it should be taught. **All twelve programs emphasize hands-on science, inquiry strategies, and student decision making.** While in most elementary schools there is a strong mismatch between the science curriculum and what 90% of students want and need, these twelve are teaching, not for the next level or test, but for science literacy; for understanding and enjoyment. Rather than emphasizing only the production of scientists, these exemplary elementary science programs focus on educating students to appreciate and use science in all walks of life. And, it works. While the last national assessment found elementary students not liking science as well as most other subjects, students in those twelve programs rank science very highly. At Porter-Gaud (Chapter 9) for instance, students at every grade level rank science as number one, even with recess as a possible choice!

Teachers, too are enthusiastic about teaching science in these programs. Teachers in these programs find science not only rewarding, but easy and enjoyable as well. Part of the ease comes from organization and the rest from intensive inservice. For organization and management, many of the larger districts hae developed science kits which are kept ready in a central office and circulated to schools on a rotating schedule. Coordinators in Anchorage, Greenville, Mesa, and Schaumburg (Chapters 3, 5, 7 and 11) say kits reduce preparation time, remove excuses for not teaching science, and allow inservice to be more directly related to what will be taught.

While most schools nationally have what has been described as a "teacher-by-teacher" program where the quantity and quality of science instruction is unknown, these twelve programs have science that is well-known and organized. As a result, not only does inservice take on a new relevance but supervision and teacher evaluation become more useful and less arbitrary. And, with more time spent on science; with instructional strategies and materials aimed at science literacy, student test scores are up in a number of the programs. Or, like at the Cornelius Math/Science Academy (Chapter 4) daily attendance is up -- for both students and teachers! This enthusiasm does not die; most programs report that their students take more than the average number of elective science courses in high school. Teachers are not immune from this enthusiasm, either. Teachers in these twelve exemplary programs average 12.7 years in their district, two more than the national average. They also are more recent in the college coursework and, in a self-report, state they are well qualified to teach science, math, social studies and reading. But, their national counterparts say they do not feel well-qualified in science, math, and social studies.

Teachers claim ownership of these programs. These programs were designed, developed, and implemented by teachers after inspiration by college courses or workshops. Two of the districts (Shaumburg and Mesa) even go so far as to state that they thought of teachers, not students as they developed their programs. While this sounds contrary to "think of students first" these districts knew that if teachers were comfortable with a program -- knowledgeable of its content and competent in its delivery -- they would teach science and students would benefit. They were right on every count. Now, in almost every program, commerically available textbooks are references and resources rather than the curriculum. Several programs, such as Ames, Iowa (Chapter 8), Newton, Kansas (Chapter 10) and Warwick, Rhode Island (Chapter 6) have developed extensive science guides which are more than textbooks. Often, teachers, when asked about texts, said "Our textbooks supplement our curriculum." Other than the exemplars, we haven't heard that very often. In fact, when we asked, "What would cause your program to fail?" we heard over and over, "Adopt a textbook!"

Interestingly, though, several programs do use a basal text, but more as an organizer for the science kits which circulate to classrooms. They envision changing texts every five years while the kits remain. Actually, all of the programs see themselves as still evolving, looking for a better way to teach more relevant science. Much of this evolution comes about as teachers take college courses and workshops, read journals such as **Ranger Rick** or **Science and Children**, or attend professional science teacher meetings. Thirty-three percent of the teachers associated with these twelve exemplars attended at least one national professional meetings in the last five years. An amazing 44% have made a presentation at a professional gathering. Several programs said they got much of their inspiration and many of their ideas from atttending professional meetings. Now, having come full circle, they go to present their ideas.

These programs have worked at making teachers feel more professional by involving and supporting them. It is their curriculum and they have a vested interest in learning how to make it work. While nationally, only 38% of elementary teachers see inservice as useful, fully 67% of these elementary teachers in exemplary programs responded in this positive way. **Inservice is often run by practicing teachers using actual materials and strategies which will later be used in classrooms.** And, inservice is seen by all exemplary schools as a long-term effort which is never-ending. Jefferson County, Colorado (Chapter 13) established an Inservice Academy which offers such programs. At JeffCo, each new elementary teacher receives three days of intensive science inservice for the grade level they will be teaching. And, if they change grade levels they get another three days of inservice while a substitute covers their classes! This is relevant inservice which helps them directly in their classrooms.

Much of this relevance to teachers comes through their own involvement but they also are encouraged by the strong administrative support they receive. In general, teachers in these programs view principals and other administration as allies and friends. In a number of programs, the original impetus for developing an innovative science curriculum came from an administrator. Relevance comes also from an extensive use of community resources; speakers, museums, industry, and environmental areas. By involving the community, teachers have made supporters of community leaders and turned parents into activists. Santa Cruz, California has gone so far as to establish a non-profit corporation, Friends of the Harvest, to support one program in an elementary school. Friends of the Harvest secures funding and support and provides publicity, aids dissementation, and generally encourages good science education.

These programs are not expensive; they rely on many commercially available activities, almost always **Elementary Science Study (ESS)** or **Science Curriculum Improvement Study (SCIS)** materials. What makes them unique is their reliance on hands-on materials and well thought-out teacher behaviors and instructional strategies. In large districts, material availability in each classroom is assured by science kits delivered from a central office. Smaller districts and schools tend to rely on the initiative of teachers interested in science. And, a majority of the science in grades 4, 5, and 6 is taught by science specialists who teach several classes of science each day.

All of these programs integrate current events and societal issues into their curriculum as well as a variety of traditional science disciplines. At Lincoln City, Oregon (Chapter 12) field trips are integrated with societal issues as well.

Most indicate that there is no essential content for elementary science and that order of content is somewhat irrelevant. Generally, they design a sequence of topics to meet the convenience of distribution of kits, interest of teachers or students, or to match seasonal or current happenings. But, the most important aspect of these innovative programs is the teachers themselves. These teachers, reflecting the goals of their programs, provide a student-centered learning atmosphere which is flexible, heterogeneous, locally relevant, and experience-oriented. In the process, these teachers lecture less and discuss more than elementary science teachers in general. While nationally, only 9% of teachers offer hands-on science daily, fully 57% of teachers in exemplary programs offer a daily hands-on science experience to their students. This is interesting compared to attendance at national science foundation funded institutes; 7% of elementary teachers in general attended NSF institutes while 27% of the teachers in these programs attended such federally funded programs.

The classroom atmosphere they create is stimulating and accepting. They expect different students to achieve differently and the search is for solutions not the correct answer. Teachers provide systematically for feelings, reflections, and self-assessment by students. There is a concern for effective communication skills and the expectation that students will question facts, teachers, authority, and knowledge.

Frequently using societal issues as a focus and rarely viewing classroom walls as a boundary, these teachers work easily with community leaders, administrators, and parents as well as children. And, teachers in these schools and systems are generally working closely with faculty of colleges and universities. Often college faculty are used as consultants and workshop leaders. Other times they work with schools developing materials and strategies, working with students outside of school, or aiding in evaluation efforts. Sometimes it is the schools helping the universities. For example, in Ames, Iowa we found an elementary classroom with remote video cameras and microphones transmitting to a teacher education class at Iow State University. There, preservice teachers could watch an actual class in action, discussing it as they progress. How many elementary science teachers would feel comfortable knowing that someone could watch them at any time without their knowledge?

These schools and districts recognized early that science is a basic part of their curriculum. In doing so, they also took advantage of the fact that children seem naturally to enjoy science and that science is easily related to all aspects of the school curriculum at the elementary level. As a result, these excellent science programs are having a visible impact on other school programs as well as other schools. They are finding that students, teachers, and parents are coming to expect science to be interesting, fun, and relevant now and in the future. In the process they are gaining even more support to continue and up-grade their programs while allowing for a positive evolution.

Students themselves are experiencing more school science that closely mirrors the nature of science itself; a condition that must enhance science literacy, attitude toward science, and an awareness of careers in science and science related fields. Teachers are feeling more professional and competent because, for the first time for many of them, they are finding they can do a good job with science while enjoying it.

We feel these examples from the Search for Excellence will motivate and inspire teachers, schools, and school districts to seek innovation and science literacy for their students. We also hope that these programs influence colleges and universities preparing teachers for elementary schools. All of these influences should ultimately affect students and lead to excellence for our educational enterprise in general.

Although many features of these programs are transportable to other schools and settings, probably no one program is the ideal one for your school or district. We hope that you will take aspects of the models we have examined, adapt their ideas to your settings, and work creating your own exemplary elementary science program. Just as there is no essential content for elementary science there is no single program which best meets the needs of all students. We do feel, however, that there are some aspects and elements that will always be present in an outstanding elementary science program.

Teachers in exemplary elementary science programs:

* **Provide** a stimulating environment.

* **Promote** inquiry strategies.

* **Are** very professional.

* **Play** a major role in their own curriculum.

* **Include** many aspects of the synthesis criteria from chapter 1.

* **Provide** systematically for feelings, reflections, and assessment.

* **Encourage** pragmatism while expecting students to question, facts, teachers, authority, and knowledge.

* **Want** to see students applying knowledge rather than merely knowing it.

Students in exemplary elementary science programs:

* **Actively** do science.

* **Identify** problems as well as solve them.

* **Make** decisions relating to their science study and their science activities.

* **Learn** how to learn

* **Do** not view the classroom walls as a boundary.

* **Develop** effective communication skills, understanding of science and the scientific enterprise, and use of their science knowledge.

Administrators of exemplary elementary science programs:

* **Support** good science programs.

* **Become** involved in elementary science.

* **Provide** systematically for availability of science materials and inservice related to science teaching.

* **Identify** key science teachers as leaders in the Search for Excellence in elementary science.

The community desiring an exemplary elementary science program will:

* **Recognize** the importance of good elementary science programs.

* **Support** science programs both at the developmental and maintenance stages

* **Demand** their children receive a science education which assures them of science literacy and an ability to live and work in the technological age of the future.

These ideas are not prescriptive of what you must do; they are descriptive of what others have done to meet the needs and challenges of their own community. To do the same in yours, you must make your own assessment and prescription by determining how best to meet your needs. We assume you will recognize in these chapters many of the problems which you too face and we hope that you will see some solutions which match your interest and needs and the support available in your own setting. We hope as well that you are stimulated to try and achieve excellence in your own program and we encourage you to write, call, or visit any of all of these outstanding programs as you design a true science learning environment in your elementary school or classroom. We have no doubt that instituting such a learning environment with your students will lead to many positive rewards and a desire to continue evolving, improving, and building on your elementary science curriculum. We have no doubt that you, teachers, and most of all, your students will treasure, remember, and use their experience in promoting a better life for themselves and their fellow citizens.